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9904

UNIVERSAL COUNTER-TIMER

RACAL-DANA

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RACAL

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RESUSCITATION

TREATMENT OF THE NON-BREATHING CASUALTY

1 SHOUT FOR HELP. TURN OFF WATER, GAS OR SWITCH OFF ELECTRICITY IF POSSIBLE

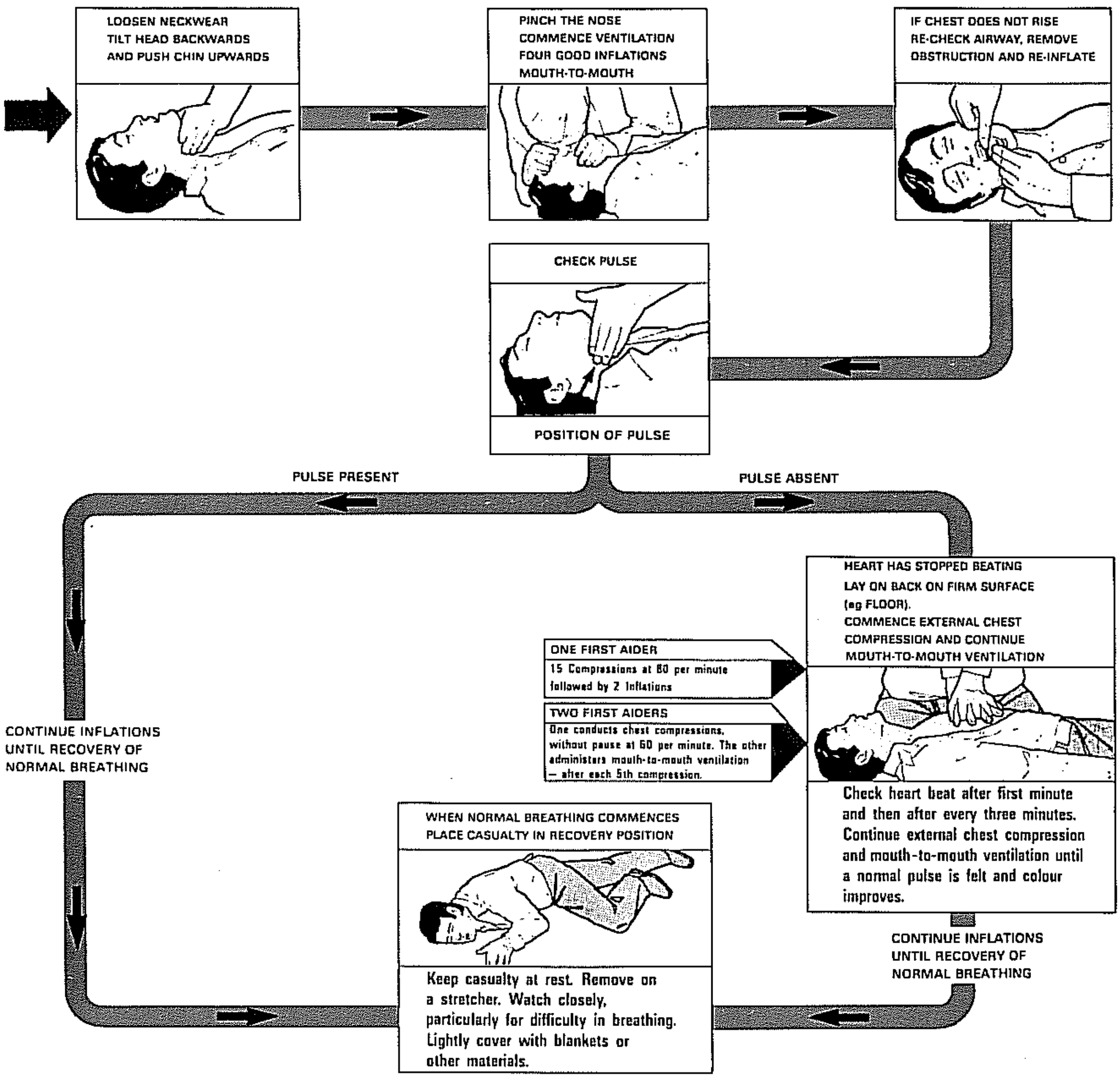
Do this immediately. If not possible don't waste time searching for a tap or switch.

2 REMOVE FROM DANGER: WATER, GAS, ELECTRICITY, FUMES, ETC.

Safeguard yourself when removing casualty from hazard.
If casualty still in contact with electricity, and the supply cannot be isolated, stand on dry non-conducting material (rubber mat, wood, linoleum).
Use rubber gloves, dry clothing, length of dry rope or wood to pull or push casualty away from the hazard.

3 REMOVE OBVIOUS OBSTRUCTION TO BREATHING

If casualty is not breathing start ventilation at once.



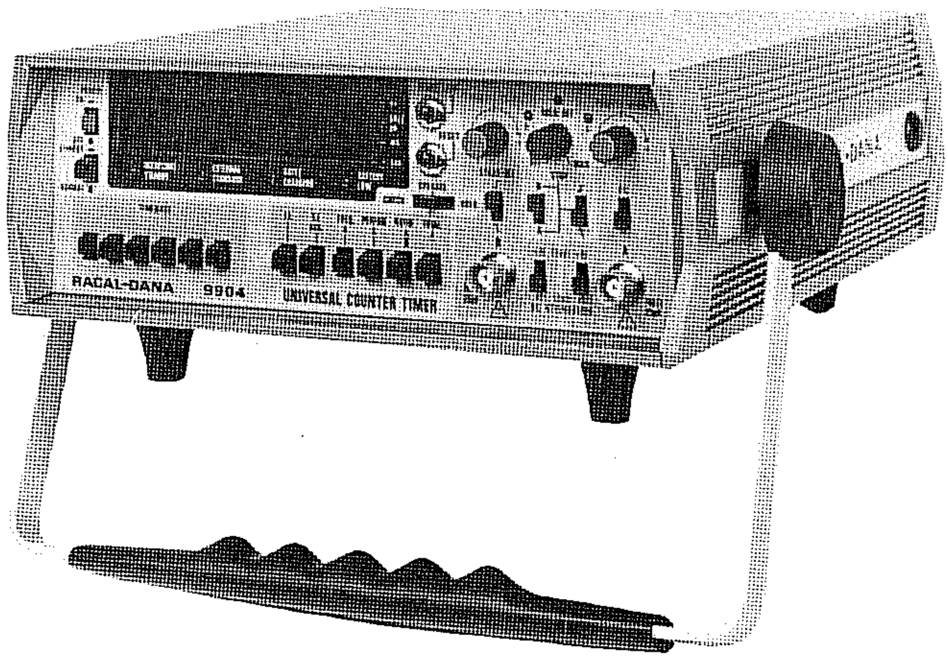
SEND FOR DOCTOR AND AMBULANCE

DOCTOR	AMBULANCE	HOSPITAL	Nearest First Aid Post
TELEPHONE	TELEPHONE	TELEPHONE	

LETHAL VOLTAGE WARNING

VOLTAGES WITHIN THIS EQUIPMENT ARE SUFFICIENTLY HIGH TO ENDANGER LIFE.

COVERS MUST NOT BE REMOVED EXCEPT BY PERSONS QUALIFIED AND AUTHORISED TO DO SO AND THESE PERSONS SHOULD ALWAYS TAKE EXTREME CARE ONCE THE COVERS HAVE BEEN REMOVED.



RACAL

WOH 8155

Universal Counter Timer 9904

HANDBOOK AMENDMENTS

Amendments to this handbook (if any), which are on coloured paper for ease of identification, will be found at the rear of the book. The action called for by the amendments should be carried out by hand as soon as possible.

'POZIDRIV' SCREWDRIVERS

Metric thread cross-head screws fitted to Racal equipment are of the 'Pozidriv' type. Phillips type and 'Pozidriv' type screwdrivers are not interchangeable, and the use of the wrong screwdriver will cause damage. POZIDRIV is a registered trade mark of G.K.N. Screws and Fasteners Limited. The 'Pozidriv' screwdrivers are manufactured by Stanley Tools Limited.

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SECTION 1

TECHNICAL SPECIFICATION

TECHNICAL SPECIFICATION

1. **GENERAL**

Model 9904 is a seven digit 50 MHz Universal Counter Timer.

2. **MEASURING FUNCTIONS**

The modes of operation are:-

(1) Frequency
(2) Single and Multiple Period
(3) Single and Multiple Ratio
(4) Single and Double Line Time Interval
(5) Single and Double Line Time Interval Averaging
(6) Totalizing

3. **DISPLAY**

Format:	Seven digit in-line, seven segment l.e.d. display. The decimal point positioning is automatic.
Latch:	The display is latched for Frequency, Period and Ratio measurement, and automatically unlatched in all other modes.
Display Time:	Gate time + 0.15s in Frequency, Period and Ratio modes. 1.5s in other modes. A switched HOLD position is provided.
Measurement Check:	Counter reads 1 MHz.
Segment Check:	Sets all numerical indicators to 8.
Reset:	Normally automatic, but a push-button for manual operation is provided.
Overflow/Standby Indicator:	Lights when overflow occurs or when instrument is in the Standby mode.
Gate/Charging Indicator:	Lights when the main gate is open or when the internal batteries are on full charge rate.
Battery Low Indicator:	Lights when internal batteries require charging.
Units Indicators:	Light to indicate the appropriate units for the display.
External Standard Indicator:	Lights when the instrument is operating from an external standard.

4. CHANNEL 'A' INPUT - AC COUPLED

Frequency Range:	10 Hz to 50 MHz.
Sensitivity:	10mV r.m.s. A variable sensitivity control is provided.
Maximum Signal Level:	250V r.m.s. up to 20 kHz. 50V r.m.s. up to 100 kHz. 10V r.m.s. above 100 kHz.
Maximum Input Level:	The d.c. level + peak signal level must not exceed 400V over the full frequency range.
Input Impedance:	1 MΩ in parallel with approximately 25pF, falling to 100kΩ at 4V r.m.s. with sensitivity control in 10mV position.

5. CHANNELS 'A' and 'B' - DC COUPLED

Frequency Range:	'A' Channel : d.c. to 20 MHz. 'B' Channel : d.c. to 10 MHz.
Pulse Duration:	25ns minimum at trigger points.
Trigger Levels:	± 3V or ± 30V nominal, with switched zero offset position. Trigger lamps flash to indicate when the input level is passing through the input hysteresis threshold.
Sensitivity:	± 140mV about offset level for ± 3V offset. ± 1.4V about offset level for ± 30V offset.
Attenuator:	X10 attenuator selected by front panel switches, giving increased offset with reduced sensitivity.
Input Impedance:	With attenuator at X1: 1MΩ in parallel with approximately 25pF, falling to 100kΩ at ± 5V r.m.s. With attenuator at X10: 1MΩ in parallel with approximately 25pF, falling to 900kΩ at ± 50V r.m.s.

Maximum Input Level:	With attenuator at X1: 100V r.m.s. up to 1 MHz, decreasing to 10V r.m.s. at 20 MHz. With attenuator at X10: 100V r.m.s. up to 1 MHz, decreasing to 40V r.m.s. at 20 MHz.
Hold Off:	Permits inhibition of the stop signal in Time Interval and Totalize modes for a period variable from 0.1 to 100ms. The delay can be displayed by selecting CHECK and Time Interval mode.
Start Inhibit:	Permits inhibition of the start signal in Time Interval and Totalize modes.

6. FREQUENCY MEASUREMENT

Input Channel:	Channel 'A'
Coupling:	AC or DC
Frequency Range:	AC coupled: 10Hz to 50MHz DC coupled: d.c. to 20MHz
Gate Times:	1 ms to 100s in decade steps.
Accuracy:	± 1 count ± frequency standard accuracy.

7. SINGLE AND MULTIPLE PERIOD MEASUREMENT

Input Channel:	Channel 'A'
Coupling:	AC or DC
Range:	1μs to 10s
Clock Unit:	1μs
Periods Averaged:	1 to 10^5 in decade multiples.
Accuracy:	$\frac{\pm 0.3\%}{\text{Number of periods averaged}}$ ± frequency standard accuracy ± 1 count. (at 50mV r.m.s. input with 40 dB S/N ratio)

Bandwidth:	Automatically reduced to 10MHz (3dB) when on AC and Period mode is selected.

8. TIME INTERVAL - SINGLE AND DOUBLE LINE

Input Channel:	Single Line: Channel 'B' Double Line: Start Channel 'B' Stop Channel 'A'
Time Range:	100ns to 10^5s (28 hours)
Clock Units:	100ns to 10ms
Start and Stop Signals:	Electrical or contact.
Manual Start and Stop:	By single push button on front panel.
Trigger Slope Selection:	Electrical: positive or negative slopes of both Start and Stop signals can be selected.
Accuracy:	± 1 count ± trigger error ± frequency standard accuracy. Trigger error: (in ns) $\frac{5}{\text{Signal slope at trigger point (V/µs)}}$

9. TIME INTERVAL AVERAGING - SINGLE AND DOUBLE LINE

Input Channel:	Single Line: Channel 'B' Double Line: Start Channel 'B' Stop Channel 'A'
Time Range:	150ns to 1s
Dead Time Between Intervals:	150ns minimum
Clock Unit:	100ns
Time Interval Averaged:	1 to 10^5 in decade multiples.
Accuracy	± Frequency standard accuracy ± system error ± averaging error. System error: 10ns maximum per input channel. This is the difference in delays between start and stop signals and can be minimised by matching externally.

Averaging error: $\frac{\text{Trigger Error} + 100}{\sqrt{\text{Intervals Averaged}}}$
in ns

Trigger error: $\frac{5}{\text{Signal slope at trigger point (V/}\mu\text{s)}}$
in ns

10. RATIO

Higher Frequency Input:	Channel 'A': AC coupled; 10Hz to 50MHz DC coupled; d.c. to 20 MHz
Lower Frequency Input:	Channel 'B': d.c. to 10MHz.
Accuracy:	± 1 count ± trigger error on Channel 'B'
Reads:	$\frac{\text{Frequency A}}{\text{Frequency B}} \times n$
Multiplier n	1 to 10^5 in decade multiples.

11. TOTALIZING

Input Channel:	Channel 'A': d.c. to 10MHz.
Maximum Rate:	10^7 events per second.
Pulse Width:	50ns minimum at trigger points.
Prescaling:	Events can be prescaled in decade multiples (n) from 1 to 10^5.
Reads:	$\frac{\text{Number of input events}}{n}$ $^{+1 \text{ count}}_{-0}$
Manual Start and Stop:	By single push button on front panel.
Electrical Start and Stop:	By electrical signal applied to Channel 'B'.

12. FREQUENCY STANDARD

Frequency:	5 MHz
Type:	Refer to Options 04A, 04B and 04C on page Tech.Spec.(7).

Frequency Standard Output:	A 1 MHz rectangular waveform is available at the rear panel BNC socket. This is t.t.l. compatible (600mV peak to peak into 50Ω).

13. EXTERNAL FREQUENCY STANDARD

Frequency:	1 MHz
Waveform:	Sinewave or pulse (up to 4:1 mark/space ratio).
Input Socket:	Applied to the Channel 'B' input. Provides an external standard for Frequency and Period measurement only.
Indicator:	A front panel l.e.d. lights when the external standard is present. Change over from internal to external standard is automatic.

14. EXTERNAL SIGNALS

Data Output:	Eight digits with overflow and decimal point in serial BCD form at standard t.t.l. level. Refer to Supplementary Data on page Tech. Spec. (10).
Other Outputs:	See Supplementary Data on page Tech. Spec. (10).
Inputs:	Reset and print hold.

15. POWER REQUIREMENTS

Voltage Ranges(a.c.)

Appropriate transformer connections allow six pairs of voltage ranges to be selected. A rear panel switch selects either the upper or lower range of each pair.

(1) 94-106V/106-119V
(2) 106-119V/118-132V
(3) 188-212V/200-225V
(4) 200-225V/212-238V
(5) 212-238V/224-251V
(6) 224-251V/235-265V

Refer to Chapter 5 for setting instructions.

Frequency: 45 to 450 Hz.

Consumption: 19VA approximately.

16. ENVIRONMENTAL & SAFETY SPECIFICATIONS

Operating Temperature Range:	0°C to +55°C (to +40°C with Battery Option)
Storage Temperature Range:	-40°C to +70°C (to +60°C with Batteries)
Humidity:	95% r.h. at +40°C.
Mechanical:	Tested in accordance with IEC 68. (BS2011 recommendations).
Safety:	Meets IEC 348 (BS4743) recommendations.

17. MECHANICAL

Dimensions:	Height: 83 mm (case only) 110 mm overall Width: 240 mm (case only) 284 mm overall Depth: 268 mm
Weight:	2.7kg (excluding battery pack) Battery pack 1.5kg.

18. OPTION 01 SERIAL TO PARALLEL INTERFACE

Data Control Information:	8 decades of data in 4 line BCD weighted 1248, 3 line decimal point position, print command, print hold, reset, overflow and time-base information. All logic levels are t.t.l. compatible.

19. OPTION 04A FREQUENCY STANDARD 9442

Type:	A fast warm up, ovened precision oscillator suitable for the majority of operations.
Frequency:	5MHz.
Ageing Rate:	± 3 parts in 10^9/day averaged over a minimum of 10 days after 3 months continuous operation.

Warm-up Time:	Better than ± 2 parts in 10^7 within 6 minutes.
Temperature Stability:	Better than ± 3 parts in 10^9 per °C over the range -10°C to +45°C, but operable to +55°C.

20. OPTION 04B FREQUENCY STANDARD 9421

Type:	An ovened oscillator of the utmost precision for use when the highest long term accuracy is essential. Not available when the Battery Pack option is fitted.	
Frequency:	5 MHz.	
Ageing Rate:	Initial:	± 2 parts in 10^9 per day averaged over a minimum of 10 days at shipment.
	Long Term:	± 5 parts in 10^{10}/ day averaged over a minimum of 10 days after 3 months continuous operation.
Warm-up Time:	Better than ± 1 part in 10^7 within 20 minutes.	
Temperature Stability:	Better than ± 6 parts in 10^{10} per °C averaged over the range -10°C to +45°C, but operable to +55°C.	

21. OPTION 04C FREQUENCY STANDARD 11-1254

Type:	An unovened crystal oscillator for non-critical applications or where an external house standard is to be used.
Frequency:	5MHz.
Temperature Stability:	± 8 parts in 10^6 over temperature range 0°C to +55°C. ± 3 parts in 10^6 over temperature range +20°C to +40°C.
Average Ageing Rate:	± 1 part in 10^6 per month three months after delivery but less than ± 1 part in 10^5, in the first year.

22. BATTERY POWER PACK OPTION: 11-1289

Mechanical:	The battery pack is mounted on a metal tray inside the instrument, and connected via a polarised 4 pin connector to the main p.c.b.
Selection:	By means of 3 position LINE POWER/CHARGE/BATTERY POWER switch on rear panel.
Battery Life:	$4\frac{1}{2}$ hours minimum continuous operation at +20°C, 15 hours minimum on standby at +20°C.
Battery Condition Indicator:	A front panel l.e.d. lights when batteries require charging.
Charge Time:	14 hours at +20°C.
Standby Facility:	With the NORMAL/STANDBY switch in STANDBY position only the internal standard is operational. Pressing the RESET button activates the counter for approximately one minute, after which it reverts to the standby condition.

23. ACCESSORIES

Accessories Supplied:	Operators Handbook Spare fuses.
Accessories Available:	Rack mounting kit (11-1126) Rigid carrying case (15-0450) Padded carrying case (15-0444) Data output connector (23-5147)

SUPPLEMENTARY DATA

DATA OUTPUT CONNECTIONS

A1. Data and command information is provided on a 28-way edge connector accessible via a removable cover on the rear panel. The facilities and pin connections are listed in Table 1 below. The logic for time base and function data is given in Tables 2 and 3.

TABLE 1

Data Output Socket

Pin	Facility	Pin	Facility
1	-5V (nominal)	A	0V
2	+5V (nominal)	V	$\overline{\text{Overflow}}$ (static indication)
3	Key Way	C	Key Way
4	$\overline{4}$ (BCD)	D	$\overline{1}$ (BCD)
5	$\overline{8}$ (BCD)	E	$\overline{2}$ (BCD)
6	$\overline{\text{External Hold}}$ Input	F	10kHz Sync.
7	$\overline{\text{External Reset}}$ Input	H	$\overline{\text{Main Gate}}$
8	Not Used	J	$\overline{\text{Start Inhibit}}$
9	$\overline{c}$) Function	K	$\overline{z}$) Time Base
10	$\overline{b}$) Information	L	$\overline{y}$) Information
11	$\overline{a}$) (See Table 2)	M	$\overline{x}$) (See Table 3)
12	$\overline{R(0)}$	N	Not Used
13	$\overline{\text{Hold/Reset}}$	P	Not Used
14	Not Used	R	Not Used

NOTES 1 External Hold Input

To extend the cycle time the external hold signal (logic '0') must be applied during the gate or hold time. To initiate a new measurement cycle the external hold must go 'high' for not less than 200μs.

2 External Reset Input

To apply external reset the level at pin 7 must go to logic '0' for not less than 5ms. On reverting to '1' level the display resets to 'all zeros' and a new measurement commences.

FUNCTION AND TIMEBASE LOGIC CODES

Function Data

A2. Function information format: 3 lines coded as shown. The table gives the logic available at the edge connector. The inverse levels are applied to the CDI Chip in the instrument.

TABLE 2

Function Information

FUNCTION	Code $\bar{a}$	$\bar{b}$	$\bar{c}$
Frequency	1	1	1
Average Period	0	1	1
Totalize $\frac{A}{n}$	0	1	0
Ratio $n\frac{A}{B}$	1	1	0
T.I.(single line or double line not averaged)	0	0	1
T.I.(single line or double line averaged)	1	0	1

Time Base Selection Data Output

A3. Time Base information: 3 lines coded as shown. The inverse levels are applied to the CDI Chip in the instrument.

TABLE 3

Time Base Selection

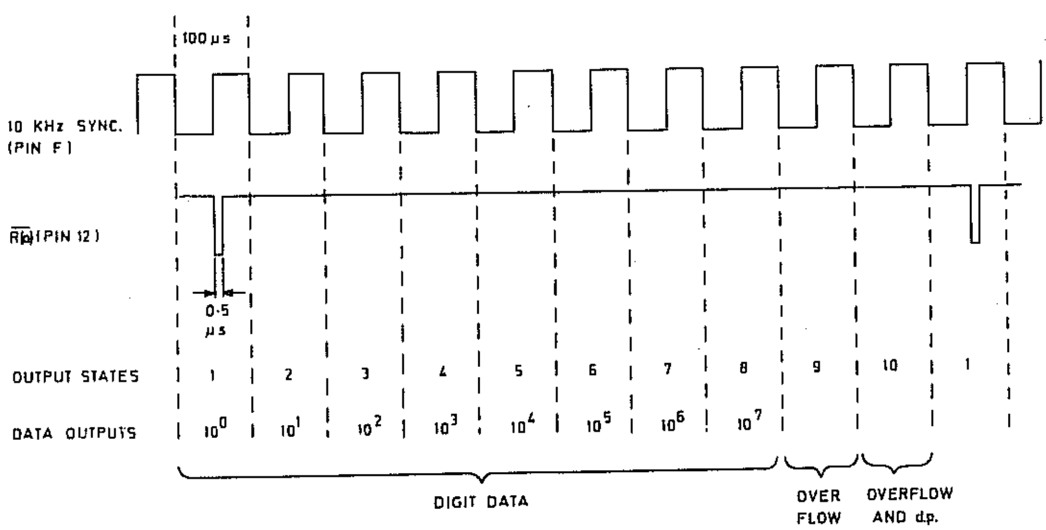
$\bar{x}$	Code $\bar{y}$	$\bar{z}$	Frequency Gate Time	Multiplier 'n'	Time Interval Clock
1	1	1	1ms	1	0.1μs
0	1	1	10ms	10^1	1μs
1	0	1	100ms	10^2	10μs
0	0	1	1 sec	10^3	100μs
1	1	0	10sec	10^4	1 ms
0	1	0	100sec	10^5	10ms

DATA OUTPUT FORMAT

A4. In standard format the b.c.d. output data is available at the 28-way edge connector in a bit parallel byte serial form. The data is sequenced by a 10 kHz synchronising signal. The data presentation is delayed 0.5µs from the negative edge of the synchronising signal. An additional synchronising pulse R(0) determines the first state (10^0 digit). Accessories are available to give data output in parallel form (for printers etc.) or IEC/ASCII bus compatible format.

A5. The ten data output states are as follows: the timing is shown in the diagram.

States	Facility
1 to 8	Digit (display information).
9	Overflow for 10^3, 10^4, 10^6 and 10^7 digits on pins D, E, 4 and 5 respectively.
10	Decimal point position in kHz units, plus overflow information for 10^5 digit, via pin 5.



Data Sequence Diagram Fig A.1

SECTION 2

DESCRIPTION

OPERATION & MAINTENANCE

CHAPTER 1

GENERAL DESCRIPTION

INTRODUCTION

1.1 The 9904 is a seven-digit universal counter timer, powered from a.c. line power or optional internal batteries and with a comprehensive range of facilities.

OPERATING FACILITIES

1.2 (a) Frequency measurement ranges: AC coupled: 10 Hz to 50 MHz.
DC coupled: DC to 20 MHz.

(b) Period measurement, 1 to 10^5 periods in decade steps, a.c. or d.c. coupled.

(c) Ratio measurement.

(d) Time Interval, single or double line, with manual or electrical start/stop signals, trigger slope selection.

(e) Time Interval average, single or double line, with trigger slope selection.

(f) Totalize, with electronic or manual start/stop.

1.3 In addition to the usual control facilities such as AC/DC input selection, manual Hold and Reset, Check etc., the 9904 incorporates variable a.c. sensitivity on the 'A' channel and variable d.c. offset on both 'A' and 'B' channels. Variable hold-off protection is available when using Time Interval or Totalize mode. The amount of hold-off (in milliseconds) can be displayed.

POWER SUPPLY

AC (Line Power) Supply

1.4 The instrument operates from a.c. supplies between 94 and 265 volts, 45 to 450 Hz. Tappings and a link on the line power transformer provide a choice of six voltage ranges. A rear panel switch allows selection of the upper or lower half of the chosen range. A label fixed to the rear panel should indicate the chosen range. Spare labels for ranges other than 212 to 251 V are supplied.

Battery Power Supply (Option)

1.5 The instrument can operate either from line power supplies, or from an internal battery pack containing re-chargeable nickel cadmium cells. The batteries allow $4\frac{1}{2}$ hours continuous operation from the full charged condition. A 3-position rear panel switch selects line or battery power, or full-rate charging of the batteries from the internal charging circuit. When on battery operation a warning light indicates when battery voltage is low.

Battery Charging

1.6 To fully charge a discharged battery requires 14 hours. Avoid overcharging as it will progressively reduce battery charge capacity. When the instrument is operating from line power supply the batteries receive a trickle charge which can continue indefinitely without detriment to the batteries.

Battery Economy (Standby) Facility

1.7 This facility may be used when continuous readout is not required. On BATTERY operation with the front panel POWER switch at STANDBY, the instrument is 'off' except for the internal frequency standard. If the RESET button is depressed and released the instrument will then operate normally for approximately one minute, after which it reverts to the standby condition. This operation may be repeated as required.

FREQUENCY STANDARD

1.8 At the customer's option one of three 5MHz oscillators from the Racal-Dana range can be fitted. Details will be found in the Technical Specification. Option 04C is a discrete component oscillator, and a parts list and circuit will be found in Section 3 of this manual. Options 04A and 04B should be serviced only by Racal-Dana Instrument Ltd., or their agents. For all options an aperture in the rear panel provides access for calibration.

1.9 An external standard, which will automatically over-ride the internal standard, can be applied via the front panel 'B' input socket for use in the Frequency and Period modes. A front panel l.e.d. lights when the external standard is operating.

1.10 A 1 MHz reference, derived from the standard in use, is available at the rear panel BNC socket.

CARRYING HANDLE

1.11 The instrument is fitted with a combined carrying handle and bench stand. To adjust the stand, press in the two handle bosses simultaneously, while setting the stand to the desired position.

OPERATORS MANUAL

1.12 A separate Operators manual is supplied with each instrument.

CARRYING CASE AND RACK MOUNTING

1.13 A rigid carrying case (Part No. 15-0450) and a 19-inch rack mounting kit (Part No. 11-1126) are available to order.

CHAPTER 2

OPERATING INSTRUCTIONS

POWER SUPPLY

2.1 Line Power. Before operating a new instrument or at a new location, check that the line voltage selection and fuse rating are correct (see rear panel label). Set the rear panel switch to LINE POWER.

Battery Supply (Option). Set the rear panel switch to BATTERY POWER. Set the POWER switch to ON and verify that the BATTERY LOW indicator is not illuminated.

FREQUENCY MEASUREMENT

2.2 In this mode the unknown frequency is gated to the counter decades for the gating period selected by the chosen Time Base (n) push button. For frequencies below 10 kHz the use of period mode will give greater resolution.

(1) Set the POWER switch to ON and the Normal/Standby switch to NORMAL.

(2) Set the following controls:-

(a) Function switch to FREQUENCY 'A'.

(b) AC/DC switch to AC or DC, as required.

(c) If using AC mode set the SENSITIVITY control initially to the maximum clockwise position.

(d) If using DC mode set the same control to the '0' (switched) position (fully anti-clockwise), and the 'A' Channel Attenuator to X1 or X10.

(e) CHECK/OPERATE/HOLD switch to OPERATE.

(3) Connect the unknown signal to the 'A' input socket. Ensure that there is no external connection made to the 'B' input.

(4) Select the required Time Base (n) push-button.

(5) If using AC mode adjust the SENSITIVITY control anti-clockwise to to obtain stable counting. If using DC mode adjust the same control for the required d.c. triggering level.

(6) Switching to HOLD stops the automatic updating of the display. A 'one shot' update can be obtained by pressing and releasing the RESET button.

Time Base Range Selection Frequency Mode)

Gate Opening Time	Multiplier 'n'	Display Resolution
1 ms	1	1 kHz
10 ms	10	100 Hz
100 ms	10^2	10 Hz
1 s	10^3	1 Hz
10 s	10^4	0.1 Hz
100 s	10^5	0.01 Hz

Overflow Procedure

2.3 To obtain high resolution when measuring high frequencies it may be advantageous to 'overspill' one or more of the left-hand digits. First of all, select a short gate time and record the most significant digits displayed, then select a Range button giving a longer gate time to display the less significant digits to the required resolution.

PERIOD MEASUREMENT

2.4 This mode is recommended for measuring low frequencies in the range of 10 Hz to 10 kHz with improved resolution. The incoming signal is taken to the time-base decade dividers, the output of which (selected by the Time Base (n) push-button) gates the internal reference frequency to the counter decades. The display indicates the actual value of the period of the incoming signal in microseconds. Greater accuracy is obtained by selecting a longer time base range thus taking the measurement over a greater number of periods.

Period Operation

2.5 (1) Set the POWER switch to ON and the NORMAL/STANDBY switch to NORMAL.

(2) Set the following controls:-

(a) Function switch to PERIOD 'A'.

(b) AC/DC switch to AC or DC, as required.

(c) If using AC mode, set the SENSITIVITY control initially to maximum clockwise.

(d) If using DC mode set the same control to zero offset, '0' (switched) position,and the 'A' Channel Attenuator to X1 or X10 as required.

(e) CHECK/OPERATE/HOLD switch to OPERATE.

(3) Connect the unknown signal to the 'A' input socket. Ensure that there is no external connection made to the 'B' input.

(4) Select the number of cycles to be timed by depressing the relevant Time Base (n) push-button. A greater number of cycles gives enhanced resolution but longer measuring time.

(5) If on AC mode adjust the SENSITIVITY control anti-clockwise for stable counting. If on D.C. mode adjust the same control to the required DC offset. For zero offset set the control to '0' (switched) position.

(6) Switching to HOLD stops the automatic updating of the display A 'one-shot' update can be obtained by pressing releasing the RESET button.

TIME INTERVAL (T.I. and T.I. Average)

2.6 In this mode the instrument is effectively serving as a stop-watch by counting clock pulses derived from the frequency standard. The time interval may be controlled by successive events on a single line in which case Input 'B' is used with the Stop Channel Selection switch set to 'B'.

2.7 For timing events on separate lines the Stop Channel Selection switch must be set to 'A'. The 'start' signal is applied to the 'B' Input and the 'stop' signal to the 'A' input. Trigger slopes can be selected by the START/STOP slope switches. On T.I. signals at the STOP input can be inhibited by use of the HOLD OFF control.

2.8 The T.I. mode is most suited to the measurement of single intervals such as pulse widths. A range of widths from 100 ns to several hours may be measured by selecting the appropriate clock unit.

The maximum clock rate is 100 ns, therefore resolution on short duration pulses is likely to be unsatisfactory, but can be improved by the use of T.I. Average mode, which increases resolution by the averaging of the inherent ± 1 count 'gate uncertainty' factor over a number of time intervals (1 to 10^5). It should be noted, when time averaging, that the repetition rate of the pulses under measurement must not be harmonically related to the frequency standard in use.

Time Interval Operation

2.9 (1) Set the POWER switch to ON and the NORMAL/STANDBY switch to NORMAL.

(2) Set the following controls:-

(a) Function: depress the T.I. or T.I. Avg* button, as required.

(b) On T.I. : HOLD OFF control as required.

*NOTE: On Time Interval Average (single line) the _|¯ to _|¯ and ¯|_ to ¯|_ measurement is effectively equivalent to Period mode. Therefore the user is recommended to use Period for this particular type of measurement as the accuracy is greater and the measurement time reduced.

(c) Stop Channel Selection switch: for single line select 'B'. For double line select 'A' and set the 'A' Channel AC/DC switch to DC.

(d) START and STOP switches: select required triggering polarities. (Not required for manual timing).

(e) Attenuator X1/X10 as required.

(f) CHECK/OPERATE/HOLD switch to OPERATE.

(3) Connect the input(s). For single line timing connect the external signals to Input 'B'. For double line connect the 'start' line to 'B' and the stop line to 'A'.

(4) Press the Time Base (n) button which provides the appropriate readout. One of the l.e.d. indicators will light to indicate the units of the display.

(5) For manual timing (on T.I. only) press and release the START/STOP push-button as required.

(6) Switching to HOLD stops the automatic updating of the display. A 'one shot' update can be obtained by pressing and releasing the RESET button.

RATIO $n\frac{A}{B}$

2.10 In this mode, two unknown signals are fed to inputs 'A' and 'B'. Generally the higher frequency is fed via input socket 'A' to the counter decades and the lower frequency is fed through input socket 'B' to the time-base decades, but this input arrangement may be reversed, as for example, when the lower frequency has a smaller amplitude (e.g. 10 mV) and the higher frequency a considerably larger amplitude. The display indicates the ratio $n\frac{A}{B}$ and the reading must be divided by the factor 'n' to obtain the ratio $\frac{A}{B}$.

Ratio Operation

2.11 (1) Set the POWER switch to ON and NORMAL/STANDBY switch to NORMAL.

(2) Set the following controls:-

(a) The FUNCTION switch to RATIO $n\frac{A}{B}$

(b) The AC/DC switch to AC or DC as appropriate.

(c) Attenuators X1/X10 as required.

(d) CHECK/OPERATE/HOLD switch to OPERATE.

(3) Connect the input signals to sockets 'A' and 'B'. (See para.2.10).

(4) Set Trigger Level controls as required.

(5) Press the Time Base button which gives a full display without overspill.

(6) Switching to HOLD stops the automatic updating of the display. A 'one shot' update can be obtained by pressing and releasing the RESET button.

(7) To obtain the true ratio the displayed reading must be divided by the factor 'n' indicated above the selected Time Base push button.

TOTALIZE $\frac{A}{n}$

Theoretical Considerations.

2.12 In this mode, signals on the 'A' input socket are prescaled and taken to the counter decades. The count can be controlled manually by the START/STOP button or electrically by timing signals connected to the 'B' input socket. This mode permits a number of events occurring with random timing to be counted over a chosen period.

A counter time base in Totalize mode is generally designed to reset to either 0 or 9; in either case a rounding off of the count occurs to an accuracy of ±1 count, as shown in the following table. It should be noted that the Racal counter 9904 resets to 9.

No. of i/p pulses ($n = 10^3$ selected)	Counter Display t/b reset 9	t/b reset 0	Error Reset 9	Reset 0
1	1	0	0.999	0.001
999	1	0	0.001	0.999
1000	1	1	0	0

NOTE: Using $n = 10^3$ the error of ± 1 count is relative to 'n minus one' input pulses (i.e. 999 pulses). For full resolution n = 1 could have been selected, then the error of ± 1 count would have been related to the display or the number of input pulses (i.e. 1 pulse).

Thus an increase in n division will give increase in counter range, but a decrease in resolution.

Totalize Operation

2.13 (1) Set the POWER switch to ON and NORMAL/STANDBY switch to NORMAL.

(2) Set the following controls:-

(a) The Function switch to TOTAL $\frac{A}{n}$

(b) The Stop Channel Selection switch to 'B'.

(c) Attenuators X1/X10 as required.

(d) The 'A' Channel AC/DC switch as required.

(e) The HOLD OFF control as required.

(f) The START and STOP switches to select the required trigger edge polarities.

(g) The CHECK/OPERATE/HOLD switch to OPERATE.

(3) Connect the signal to be totalized to socket 'A' and the electrical timing signals (if used) to socket 'B'.

(4) Press the Time Base button which will provide suitable units for the count. For example, if the 10^3 switch is depressed the display will be in units of 1000 (within the accuracy of measurement).

(5) Set the TRIGGER LEVEL controls as required.

(6) Switching to HOLD stops the automatic clearing of the display. The RESET button should be pressed and released before making a fresh measurement.

(7) If manual control is required, press the START/STOP button to commence counting and again to terminate counting.

(8) In order to obtain the true total the displayed reading must be multiplied by the scaling factor 'n' indicated above the selected Time Base push button (see para.2.12 for accuracy).

BATTERY ECONOMY OPERATION

2.14 (1) Prepare the instrument for battery power supply (para.2.1) and normal measurements.

(2) Set the NORMAL/STANDBY switch to STANDBY and briefly press the RESET button. The instrument will operate for approximately one minute and then revert to standby. To repeat the operation press RESET when instrument is in the STANDBY condition.

STANDBY OPERATION WITH AC POWER

2.15 The operation described in 2.14(2) can be used with line power. It may be noted that, when switching from NORMAL to STANDBY within one minute of first switching on, the display generally remains on for about one minute before setting into the 'display off' standby condition.

NOTE: The frequency standard oscillator is not switched off in STANDBY and is therefore ready for immediate use.

BATTERY CHARGING

2.16 (1) Connect the a.c. supply.

(2) Set the rear panel BATTERY POWER/CHARGE/LINE POWER switch to the CHARGE position.

(3) Set the front panel Power switch to ON. Verify that the CHARGE indicator is illuminated. The time required for a complete re-charge is 14 hours.

NOTE: The batteries receive a trickle charge when the instrument is operated with rear panel switch in the LINE POWER position.

Function Push-Button Switch Bank:

This bank of six press switches, located near the centre of the front panel, select the following measurement modes:-

(a) T.I.

Provides time interval measurement between two successive events. The events may be on one line (B-B) or separate lines (B-A), with start and stop slopes of the same or opposite polarity.

(b) T.I. Avg.

This mode is suitable for the measurement of short repetitive events, with start/stop controls as in T.I. By averaging over a number of events the resolution is increased.

(c) FREQ. A

Provides frequency measurement of the 'A' channel input with readout in kHz.

(d) PERIOD A

Provides period measurement on 'A' channel signal with readout in microseconds.

(e) RATIO $n \frac{A}{B}$

Refer to para. 2.10

(f) TOTAL $\frac{A}{n}$

Provides accumulated total of events applied to Channel 'A', prescaled by a factor 'n' which is selected by use of the Time Base (n) push buttons .

Time Base Range Push- Buttons:

This bank of six 'n' switches offers a choice of gate times, and clock units on T.I. The multiplier 'n' associated with each switch may also be defined as follows:-

(a) The number of periods averaged on 'period average' measurement.

(b) The 'A' input prescale factor on 'totalize'.

(c) The 'B' input prescale factor on 'ratio'.

(d) The number of intervals averaged on 'time interval average'.

START Slope Switch:

A slide switch which selects either positive-going or negative-going trigger edge for start of time interval and totalize measurements. Applies to Channel 'B' only.

STOP Slope Switch:

Selects the required 'stop' trigger edge polarity on time interval and totalize on Channel 'A' or 'B', according to the setting of the Stop Channel Selection switch.

Stop Channel Selection Switch:

Position B selects single line (Channel 'B' only).
Position A selects double line (Start on Channel 'B', Stop on Channel 'A').

AC/DC Switch:

This switch selects either a.c. or d.c. coupling in the 'A' channel amplifier.

Operation on DC Mode

The use of d.c. mode is recommended in the following circumstances:-

(a) For signals having a slow rate of rise and fall (e.g. sinusoidal signals of frequency lower than 10 Hz).

(b) For signals of rectangular waveform which have a mark/space ratio other than 1:1, provided the frequency is less than 10MHz.

(c) Random pulses.

A.C. SENSITIVITY and TRIGGER LEVEL ('A' Channel):

This is a dual potentiometer and switch operated by a single control, which performs two functions in the 'A' channel:-

Sensitivity

The attenuator control is operative on 'A' channel signals when the AC/DC switch is at AC. It is particularly useful in filtering out h.f. interference on lower frequency measurements.

D.C. Trigger Level

The control provides d.c. offset from -3V to +3V when the AC/DC switch is at DC. If offset is not required the control should be turned fully anti-clockwise to the switched ('0') position.
When the 'A' Channel attenuator is set to X10 the d.c. offset range becomes +30V to -30V.

TRIGGER LEVEL Control ('B' Channel)

This control operates in the same manner as the 'A' Channel Trigger Level control described above.

HOLD OFF Control

Hold Off is used on Time Interval and Totalize to inhibit the stop input for a period (variable from 0.1ms to 100ms) set by the Hold Off control. This prevents the measured interval being terminated by unwanted signals at the Stop Channel input.

START/STOP Push Button:

Provides manual start/stop on Time Interval and Totalize modes.

CHECK/OPERATE/HOLD Switch:

In the OPERATE position the instrument provides continuous updating of the display. In the HOLD position the display is held, but a single shot update can be obtained by depressing the adjacent RESET button.

In the CHECK position the following facilities are available.

(a) 1 MHz self check display

(b) With RESET button depressed an 'all 8's' display is provided for segment check.

(c) With T.I. function selected the Hold Off delay is displayed.

RESET
Push Button:

When the RESET button is depressed and released the instrument will clear down to zero and initiate a new measurement. The RESET button is also used in the segment check and for battery economy operation.

Attenuator (X1/X10) switches

With X1 selected the TRIGGER LEVEL controls have a d.c. offset range of +3v to -3v.
With X10 selected an input attenuator of 20dB is inserted. The d.c. offset range becomes +30V to -30V.

POWER ON/OFF Switch

The function of this switch is affected by the setting of the LINE POWER/CHARGE/ BATTERY POWER switch on the rear panel, and by the NORMAL/STANDBY switch.

POWER ON Position

With LINE POWER selected the a.c. supply is connected to the instrument. Trickle charging of the batteries, if fitted, will take place.

With BATTERY POWER selected the supply from the batteries, if fitted, is connected to the instrument.

With CHARGE selected the batteries, if fitted, will receive a full rate charge derived from the a.c. supply.

POWER OFF Position

In the 'off' position, the charging and operating facilities are switched off, irrespective of the type of power supply.

NORMAL/STANDBY Switch	With NORMAL selected the POWER ON/OFF switch has its full range of functions. With STANDBY selected: (a) With LINE POWER selected only the frequency standard is powered. (b) With BATTERY POWER selected the frequency standard is powered and the Battery Economy facility is available.

INDICATORS

OVERFLOW/STANDBY Indicator	The OVERFLOW indicator will illuminate when the count exceeds the capacity of the 7-digit display or if STANDBY is selected.
BATTERY LOW Indicator:	Illumination indicates that the batteries will be exhausted within a few minutes.
GATE/CHARGING Indicator:	This indicator illuminates as follows:- (a) When the counter gate is 'open'. The illumination period is related to gate time selected. (b) When the batteries are receiving full charge a steady illuminaton is obtained (at the same time the readout display will be blank).
EXTERNAL STANDARD Indicator:	This l.e.d. lights when the equipment is in the Frequency or Period mode and an external standard is connected and operating.
INPUT TRIGGER Indicators:	These l.e.d.s flash when the input signal is passing through the hysteresis threshold of the associated channel input Schmitt trigger. The indication gives assistance in setting up the d.c. TRIGGER LEVEL control.
MEASUREMENT UNITS	The 'ms', 'kHz/μs', 'ns' and 'sec' l.e.d.'s indicate the appropriate unit for the display.

DESCRIPTION OF CONTROLS (Cont'd)

HOLD OFF Indicator	This l.e.d. lights when the HOLD OFF facility is selected.

REAR PANEL ITEMS

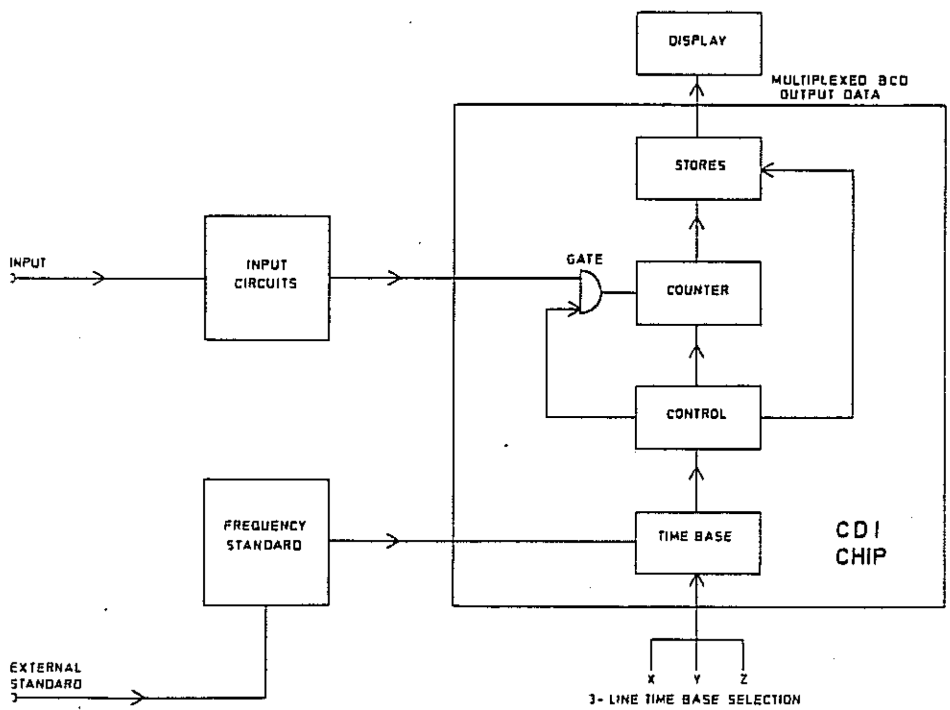
LINE POWER/CHARGE/BATTERY POWER Switch:	This switch selects the operational power source (battery or line power). The CHARGE position provides full-rate battery charging when the line power is connected and the front panel power switches are at ON and NORMAL.
1 MHz O/P Socket:	A TTL 1 MHz reference signal derived from the frequency standard in use is available at this BNC socket.
Data Output Connector:	The facilities provided by this 28-way connector are listed in Table 1 in the supplement to the Technical Specification.
Marker Output Pins:	The Marker Output Pins allow the user to monitor the state of the Schmitt triggers in the Channel 'A' and 'B' d.c. amplifiers.
Start Inhibit Pin :	A logic '0' on this pin inhibits the Start Channel, allowing unwanted signals to be rejected.
Power Plug:	A three-core power lead is supplied with the instrument.
Power Fuse:	Fuse ratings are annotated on the rear panel . A surge resisting 5 x 20 mm glass cartridge type must be used.
Osc. Adjust:	This aperture provides access to the calibration adjustment in the frequency standard unit.
Voltage Selection Switch:	This switch has two positions, 'A' and 'B'. It must be set in conjunction with selected tappings on the line power transformer. Instructions for changing voltage range are given in Chap. 5. It is important that the label adjacent to the switch shows the voltage range selected.

CHAPTER 3

PRINCIPLES OF OPERATION

THE CDI CHIP

3.1 A basic digital frequency meter comprises a chain of decade counters feeding b.c.d. data into latched stores. Counting is controlled via a main gate which is opened for a period determined by the time base. Provision is made for resetting the counter and releasing the data for display. In the 9904 these functions are carried out in the integrated circuit IC5, which achieves large scale integration, using the collector-diffusion-isolation principle. For convenience, IC5 will often be referred to in the handbook as the 'CDI Chip'.



Basic Frequency Meter Fig. 3.1

GENERAL CIRCUIT FUNCTIONS

3.2 Outside the CDI Chip, other circuit functions are carried out, such as:-

(a) Input amplification and signal shaping. Sensitivity control and input (channel) selection.

(b) A seven-digit display system in bit-parallel byte serial (multiplex) form, with data readout available for external use.

(c) Clock (reference) frequency generation using a discrete 5MHz oscillator circuit, or a high-stability temperature controlled oscillator. The reference frequency is doubled to 10 MHz for use in the CDI Chip.

(d) Trigger slope selection, variable trigger hold off, display time control and external reset are provided by means of discrete circuits.

(e) The power supply system operates from either a.c. line power or optional battery pack using re-chargeable nickel-cadmium cells. Trickle charge and full charge facilities are included. 'Charge' and 'Battery Low' indicators are provided. A 'battery economy' facility is provided.

(f) Light emitting diode (l.e.d.) indicators are provided as follows:-

(i) Overflow/Standby:- LP1 lights when the count exceeds the capacity of the seven decade counter. The same indicator lights when the NORMAL/STANDBY switch is set to STANDBY.

(ii) Battery Low: LP2 indicates the need for re-charging of the batteries. When it lights only a few minutes of battery use is available.

(iii) Gate/Charging LP3 lights in synchronism with the main gate in the counter, thus showing that measurement is in progress. When the rear panel switch is set to CHARGE the indicator shows that power is available to the charging circuit.

(iv) External Standard:- LP10 lights when an external frequency standard is connected and operating.

(v) Trigger Indicators:- LP8 and LP9 light when the input signal passes through the hysteresis threshold of the input Schmitt triggers of the 'A' and 'B' d.c. amplifiers respectively.

(vi) Measurement Units:- LP4 to 7 light to show the appropriate unit for the display.

(vii) Hold Off: LP11 lights when the Hold Off facility is in use.

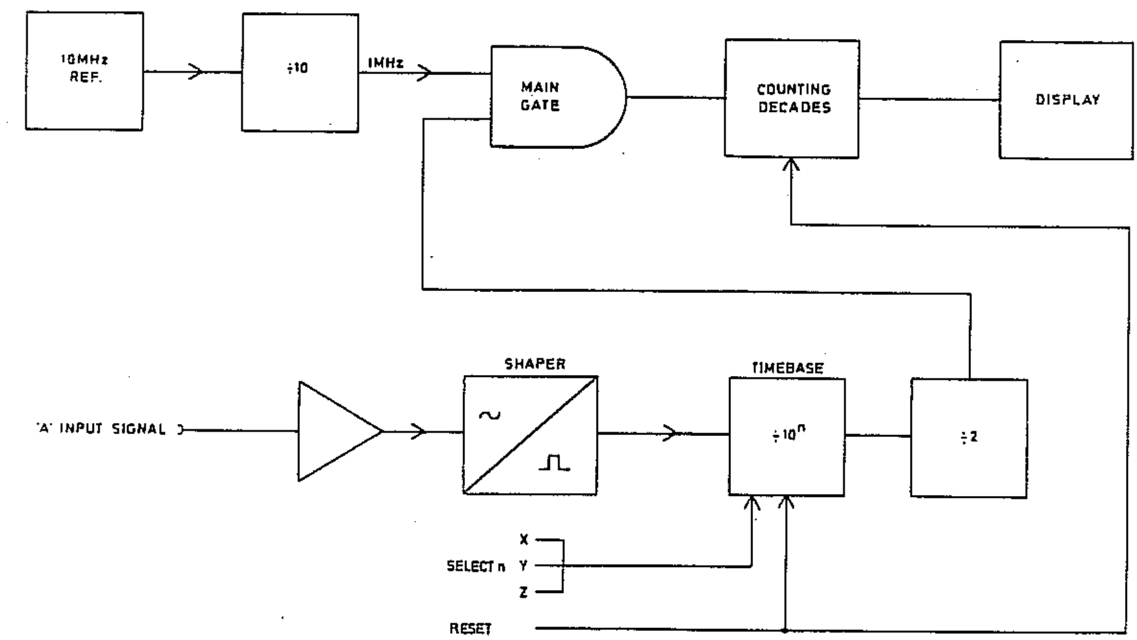
SELF CHECK

3.3 In the Self Check mode the standard frequency of 1 MHz takes the place of the unknown frequency, thus providing a check on the measurement system in the different modes. Facilities for a segment check of the display indicators are also provided.

AVERAGE PERIOD MEASUREMENT

3.4 The period of a waveform is measured by counting the number of clock pulses which occur during one or more cycles of that waveform. Greater accuracy is obtained by measuring over as many cycles as possible. As shown in Figure 3.2, the signal of unknown frequency is applied to the 'A' Input and after amplification and shaping is applied to the time base decades. In the time base the unknown signal generates a selection of gate waveforms, one of which is selected by depressing the appropriate time base (n) push-button. The chosen gating waveform is applied to the main gate to control the number of periods during which the measurement is taken.

3.5 Clock pulses from the frequency standard are fed to the signal input of the main gate and are counted during the time interval controlled by the selected time base output. The main gate then closes and the display shows the total of clock pulses counted, with decimal point positioned to indicate the average period of the signal.



Period Measurement Fig. 3.2

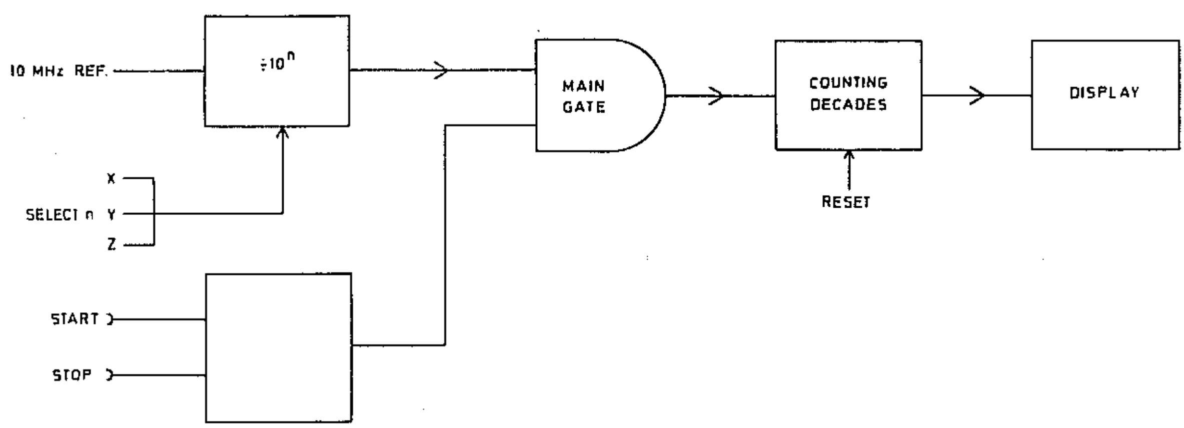
TIME INTERVAL (SINGLE LINE)

3.6 In this mode the instrument is effectively serving as a stop-watch. Start and Stop signals are supplied from an input on the 'B' channel or by operating the manual START and STOP button.. The time interval is measured by counting clock units derived from the frequency standard.

3.7 The 0.1 microsecond output from a 10 MHz frequency reference is applied to the time base decades and a suitable clock unit is selected by depressing an appropriate time base push-button. These clock pulses are then coupled to the signal input of the main gate and are totalled in the counter decades during the interval between the Start and Stop signals. At the end of the count the total of time units is displayed. The time value of the chosen unit is indicated by the units indicators.

TIME INTERVAL (DOUBLE LINE)

3.8 The operating principle is the same as for single line, except that the start and stop signals are on separate inputs. The display will read the true time interval between events on the separate 'A' and 'B' channels.



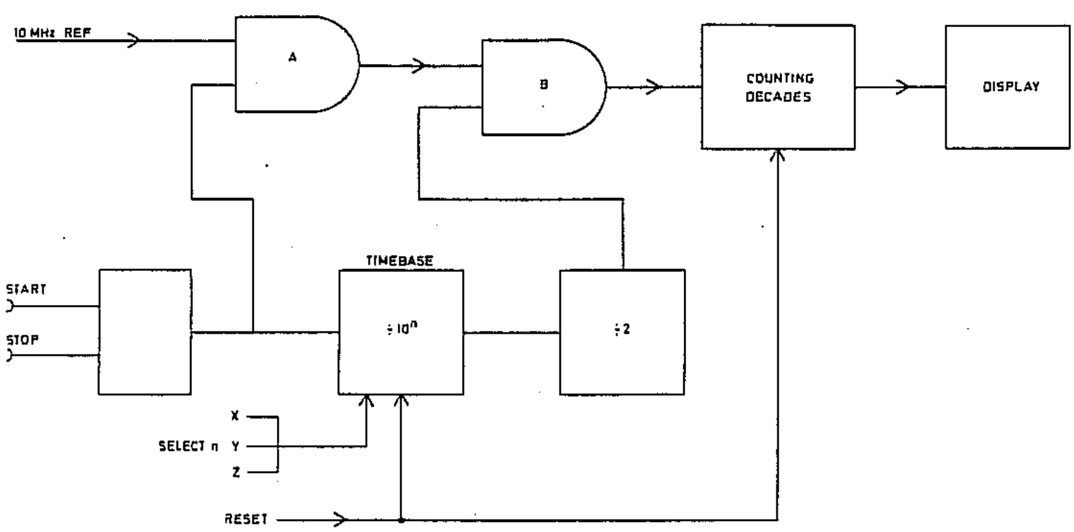
Time Interval Measurement Fig. 3.3

TIME INTERVAL AVERAGE

3.9 The reference frequency is 10 MHz. Thus the shortest available clock unit is 100 ns, which places a limit on the resolution available for measurements on, for example, narrow pulse widths. Greater resolution is achieved by the 'averaging' technique, which functions as follows:-

3.10 Referring to Figure 3.4 the clock input to the counter has to pass through two gates in series (gates 'A' and 'B' in the diagram). The successive Start and Stop pulses open and close Gate 'A' allowing 10 MHz clock pulses to pass to Gate 'B' during each 'gate open' period. Gate 'B' is held open by the time base for the selected number of intervals and the clock pulses are totalled in the counter. At the end of the selected time base period Gate 'B' closes and the count is displayed as the average time interval.

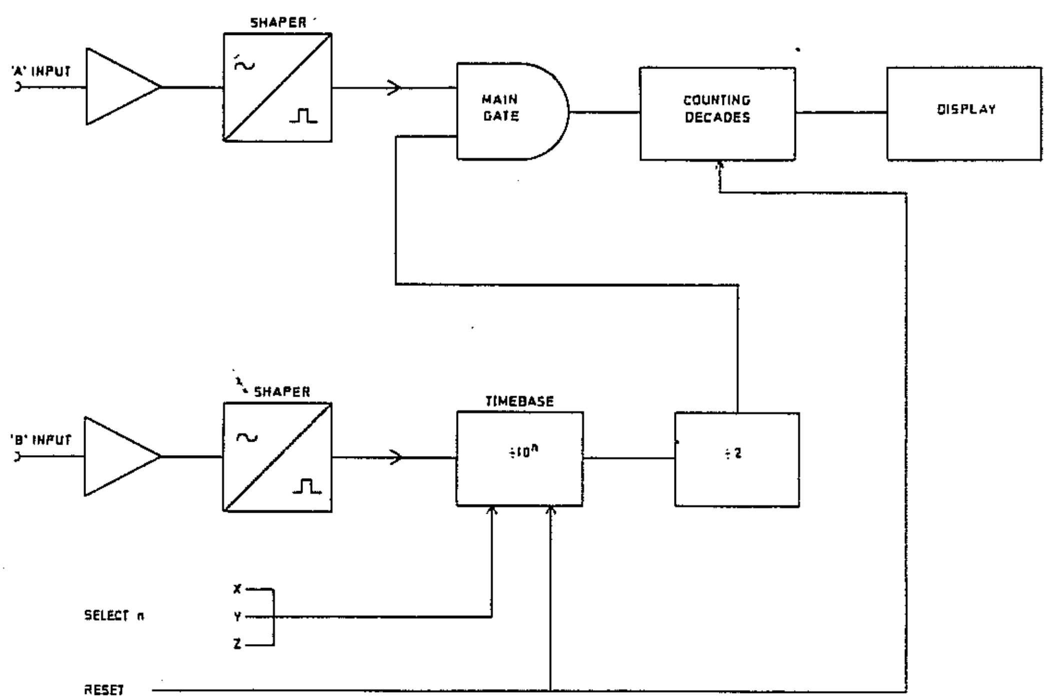
NOTE: To obtain the improved resolution from time interval averaging, the recurrence frequency of the timing input signal must not be harmonically related to the frequency standard of the counter.



Time Interval Average Measurement Fig. 3.4

RATIO

3.11 The principle of operation is very similar to frequency measurement, except that the time base output is not derived from the frequency standard. Instead, the lower of the frequencies to be compared is applied to the 'B' Input and divided in the time base. The higher frequency is applied to the 'A' Input and fed via the main gate to the counter. A waveform from the time base decades (derived from the 'B' Input) is selected to gate the 'A' channel signal by depressing an appropriate time base (n) push-button. Since the time base output is a divided version of the 'B' signal, the readout gives a count which corresponds to the ratio of the two input frequencies, multiplied by the factor 'n'. The particular 'n' factor used is that shown adjacent to the selected push-button.

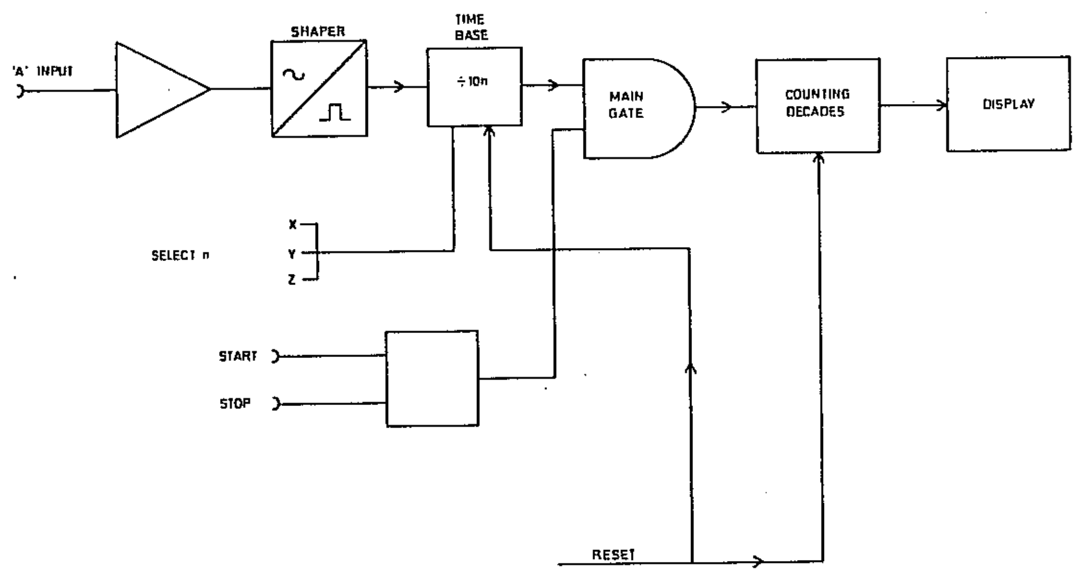


Ratio Measurement Fig. 3.5

TOTALIZE

3.12 The events to be counted are applied to the 'A' Input and, after amplification and shaping, are coupled to the input of the time base decades. An output is selected from an appropriate time base decade by depressing the relevant 'n' push-button. This scaled output is coupled to the signal input of the main gate.

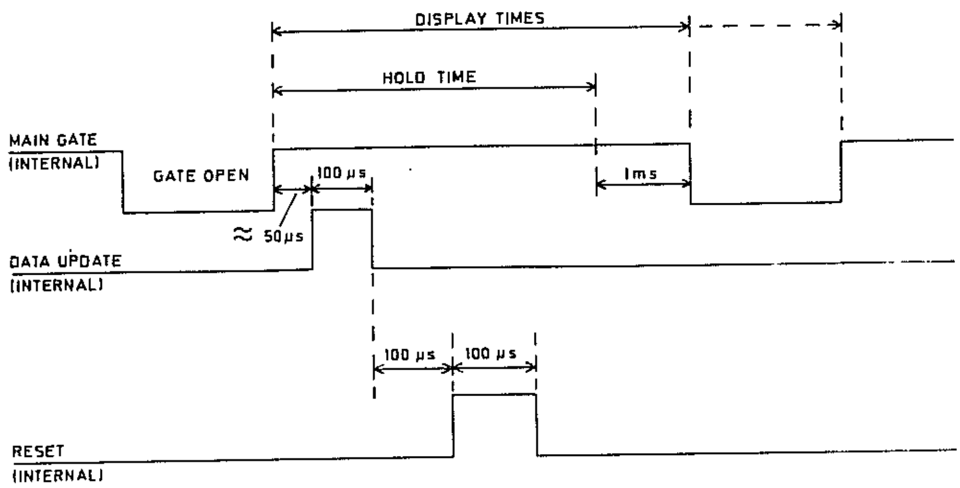
3.13 A command level from the START push-button opens the main gate and allows counting to commence; the gate is closed by a command from the STOP push-button. Automatic Start/Stop can be arranged by applying suitable control pulses to the 'B' Input socket.



Totalizing Fig. 3.6

CONTROL SEQUENCE

3.14 Figure 3.7 shows the control sequence diagrammatically (not to scale). The longer display time shown in the diagram applies to the latched modes, (Frequency, Period and Ratio).



Control Sequence Diagram Fig. 3.7

External Hold

3.15 If, when used with external circuitry, it is required to extend the cycle time, the external hold signal (logic '0') at pin 6 of the data connector, must be applied before the end of the gate or hold time. To allow a new measurement cycle to commence, the external hold input must go 'high' for not less than 200μs.

External Reset

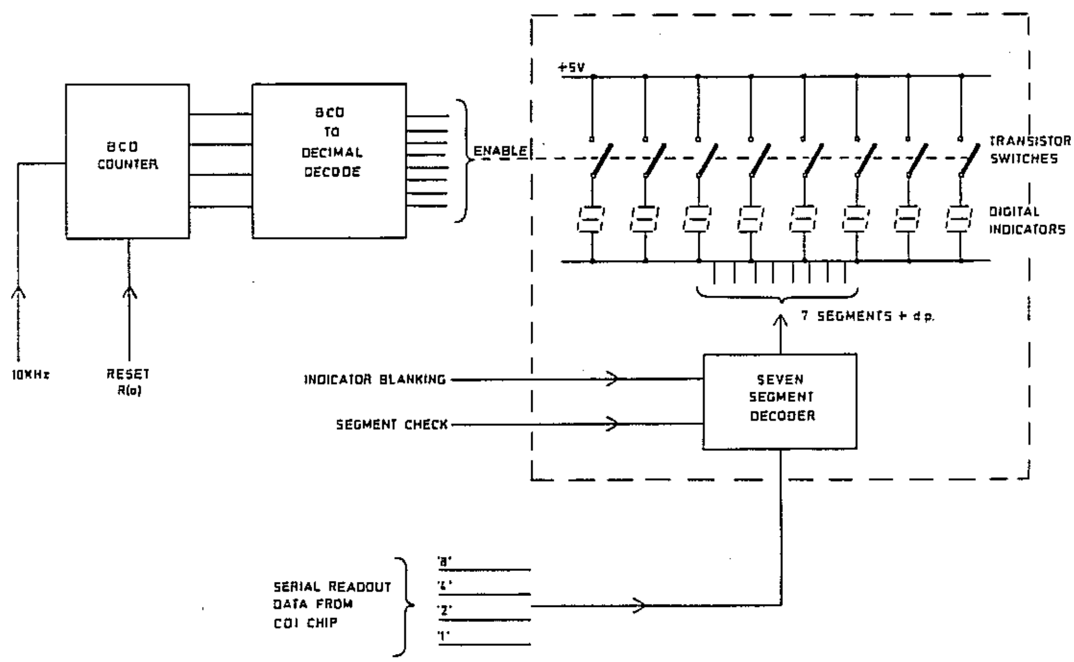
3.16 For external reset a logic '0' level must be applied to pin 7 of the Data Output connector for a period of not less than 5 ms. On reverting to '1' level the display resets to 'all zeros' and a new measurement commences.

Multiplex Readout

3.17 The readout data is fed from the CDI Chip to the display decoder via a four-wire b.c.d. connection. To permit this simple interconnection a parallel-to-serial (multiplex) system is used. The principles are shown in Fig.3.8, although it should be noted that part of the system is in the CDI Chip.

3.18 In the CDI Chip the data stores feed in parallel into a common b.c.d. four-line output. The store outputs are enabled in turn for approximately 100μs by a 10 kHz reference signal, derived from the frequency standard.

3.19 The b.c.d. data is fed to a 7-segment decoder (IC25) which offers the decoded data to the bank of l.e.d. digital indicators. The 10 kHz reference signal is fed to a BCD/Decimal decoder which 'enables' each display indicator in turn for 100 μs. A reset pulse R(o) which is generated in the 10^{0} state of the counter, ensures that the display enable is synchronised with the data store readout. A diagram showing the data output format is given on page 12 of the Technical Specification.



Multiplex Display System Fig.3.8

3.20 In the display indicators each displayed numeral is formed by illuminating an appropriate number of short straight segments. The numeral '8', for example, is formed from 7 segments, whereas the numeral '4' will require only 4 segments. The segments can be checked by selecting CHECK and pressing the RESET button. This calls up an 'all eights' display.

Decimal Point

3.21 Decimal point (d.p.) information is obtained by encoding the four line b.c.d. output data from the CDI Chip with the display enable signal. This encode turns on a d.p. drive transistor at the correct instant to light the appropriate decimal point.

Control Codes

3.22 A 3-line system is used for time base range selection. The lines are identified as x, y and z, and the logic coding is in Table 3 in the Technical Specification.

RESISTOR ARRAYS

3.23 Many of the integrated circuits are open collector types. For these IC's discrete 'pull-up' resistors are provided in the circuit. These resistors may be mounted in sealed dual-in-line (d.i.l.) packages, for example R97 (Fig.4) which has thirteen 1kΩ resistors with a common connection to +5V. Such arrays cannot be serviced and must be changed in the event of a faulty resistor.

CHAPTER 4

TECHNICAL DESCRIPTION

INTRODUCTION

4.1 Apart from some switches and certain items of the power supply, the circuit for the instrument is mounted on one main p.c.b. assembly.

LOGIC CIRCUIT SYMBOLS

4.2 Extensive use is made of integrated circuits (IC's) and these are identified by a number and suffix letter. In the circuit description a particular IC pin will be identified by a reference such as 'IC10a/2', which indicates pin 2 on that particular gate. The logic symbols used in the circuits are those found in most manufacturers IC data sheets to which reference should be made if detailed information is required. The CDI Chip IC5 is, however, available only through the Service Department of Racal-Dana Instruments Ltd.

OPERATING CONTROLS

4.3 It is assumed that the reader understands the operational function of each control, as described in Chapter 2.

FUNCTION AND RANGE SWITCHING

Switch Selection

4.4 In the circuit diagram, Figure 4 at the back of the book, the Function and Time Base push-button banks S1 and S2 are at the lower left corner. It should be noted that the PERIOD and n(1) switches are shown as selected and all other push-buttons are at 'off'. Switching functions are directed by logic signals, the +5V supply and 'pull-up' resistors being provided in the d.i.l. resistor array R95 and discrete resistors R69, 70, 71 and 72.

Control Codes

4.5 Operational modes within the CDI Chip are selected by the switch bank S1 and the $\bar{a}$, $\bar{b}$ and $\bar{c}$ lines, which are connected via inverters IC1d, e and f to IC5. Table 4a gives the logic coding at the switch connections.

4.6 Time base selection is made via switch bank S2 and lines $\bar{x}$, $\bar{y}$ and $\bar{z}$, which control the gate times in IC5 via the inverters IC1a, b and c. Table 4b gives the logic coding at the switch connections.

TABLE 4a

Function Information

Function	Code $\bar{a}$	$\bar{b}$	$\bar{c}$
Frequency	1	1	1
Average Period	0	1	1
Totalize $\frac{A}{n}$	0	1	0
Ratio $n\frac{A}{B}$	1	1	0
T.I.(single or double line not averaged)	0	0	1
T.I.(single or double line averaged)	1	0	1

TABLE 4b

Time Base Selection

Code $\bar{x}$	$\bar{y}$	$\bar{z}$	Frequency Gate Time	Multiplier 'n'	Time Interval Clock
1	1	1	1 ms	1	0.1 µs
0	1	1	10 ms	10^1	1 µs
1	0	1	100 ms	10^2	10 µs
0	0	1	1 sec	10^3	100 µs
1	1	0	10 sec	10^4	1 ms
0	1	0	100 sec	10^5	10 ms

Data Latch/Unlatch

4.7 This is determined by the logic level applied to IC5/4, as follows:-

Latch......................logic '1'
Unlatch....................logic '0'

4.8 In Totalize and the two Time Interval modes the data stores in IC5 are unlatched by a logic '0' at IC5/4. This is arranged by Function switch S1 which applies an earth to R70 when the FREQ., PERIOD and RATIO buttons are not selected.

CHECK/OPERATE/HOLD and Reset

4.9 The CHECK/OPERATE/HOLD switch 1S2 is mounted on the Display Assembly and shown on the left hand side of the circuit diagram (Fig.4). In the OPERATE position the display is continuously updated, the automatic reset being produced within the CDI Chip.

4.10 The HOLD connection to the CDI Chip is at IC5/13, the logic requirements at this point are:-

	(	Hold.............'1'
IC5/13	(	Free Run..........'0'
	(	Reset.............Transition '1' to '0'

The hold and manual reset signals are applied via the display time generator and associated circuit described in paras. 4.50 to 4.58

4.11 With the CHECK mode selected the 1 MHz standard is applied to the counter circuits to provide an operational check of counter and display in 'Frequency' and 'Period' modes. Pressing the RESET button with CHECK selected gives an 'all 8's' display for segment checking. With CHECK and T.I. selected the Hold Off time is displayed.

A CHANNEL INPUT

4.12 The 'A' Channel has alternative amplifier paths, selected by the AC/DC switch 1S1. The two amplifier paths have a common output stage (Q4) which feeds into the counter input of the CDI Chip IC5/22.

'A' Channel AC Amplifier

4.13 Signals in the frequency range 10 Hz to 50 MHz which are applied to the 'A' input socket, SK50, are fed via the AC/DC switch (AC position) and capacitor 1C1 to the SENSITIVITY potentiometer 1R1a. From 1R1a signals are fed via the C103/R202 combination to the amplifier on the main p.c.b.

4.14 The amplifier has a high impedance FET input (Q1) with overload protection provided by R202, D1 and the gate/channel diode. The output from the source of Q1 drives a wideband differential amplifier IC32 which feeds into Q3. Transistor Q2 is turned off in all modes except PERIOD. In PERIOD mode the removal of the earth by switch S1 turns Q2 on, restricting the bandwidth due to the introduction of C9.

4.15 Transistor Q3 drives the amplifier IC17c and IC17a. IC17c has feedback applied to give a Schmitt trigger action. The output from IC17a is fed to Q4.

DC AMPLIFIERS

4.16 The 'A' Channel DC amplifier and the 'B' Channel amplifier are basically identical. The description of the 'B' Channel amplifier, trigger level setting, attenuation, marker output and trigger l.e.d. drive given below applies to both circuits.

'B' Channel Amplifier

4.17 Input signals at SK51 are fed to the X1/X10 attenuator switch 1S8. This selects either the R12/C5 combination or the R10/R11 attenuator as the path to Q17.

4.18 Q17 is a dual FET. One FET is used as an amplifier, the input excursion being limited by D8 and D9. The signal from the source is fed to the inverting input of IC33a, a line receiver having feedback applied to give a Schmitt trigger.

4.19 The second FET of Q17 has its gate potential set by the 'B' Channel TRIGGER LEVEL potentiometer, and sets the potential of the non-inverting input of IC33a. This provides control of the trigger level at the input socket over the range ±3V with X1 selected and ±30V with X10 selected.

4.20 The signal from IC33a/4 is passed through IC28a, which forms part of the signal selection system described in paragraphs 4.25 to 4.29. The signal at IC28a/3 is passed via IC6a to the Marker Output pin on the rear panel.

4.21 The signal from IC28a/3 is also used to control the Trigger lamp drive unit. This circuit provides an indication as to whether the amplifier is being triggered. Successful triggering of the amplifier is indicated by flashing of the Trigger l.e.d. LP8 at approximately 10 flashes per second.

4.22 IC23e and d, R52, R53 and C37 form a multivibrator running at approximately 10Hz. The positive going edge at IC23d/8 is inverted in IC23a, differentiated by C36/R54 and used to preset IC31a. This opens gate IC24a and closes gate IC24b.

4.23 In the absence of signal at IC28a/3 (amplifier not being triggered), IC31a remains preset, and the l.e.d. drive is inhibited by IC24b. With signal present, however, the first positive going edge at IC28a/3 will clock IC31a/6 to '1'. The negative going half cycle at IC23d/8, inverted by IC23b, will give a '0' at IC24b/6. The l.e.d. will therefore light for half a cycle of the multivibrator.

4.24 With input frequencies of less than 20Hz IC31a will not necessarily be clocked out of the preset state during the multivibrator half cycle following presetting. The operation of the Trigger l.e.d. would be inhibited even though the 'B' Channel input was in the high state. To prevent this LP8 is lit via IC24a when IC31a is in the preset state and the 'B' Channel input is in the high state.

SIGNAL SELECTION

4.25 The signal at IC5/22 can be obtained from the 'A' Channel AC amplifier, the 'A' Channel DC amplifier or the 1 MHz standard at IC5/6. Selection is made by Q10, Q13, IC28b, IC16e and IC11a. All selected signals are passed through the amplifier Q4.

4.26 On 'A' Channel AC the input to the 'A' Channel DC amplifier is held at ground. The base potential of Q10 is set by R66, D2 and R36, and this connectes the -5V to the AC amplifier via Q6 and Q10. At the same time Q13 is turned off, removing the -5V supply from the 'A' Channel DC amplifier. IC11a/1 is held at '0' by IC27d, cutting off the 1MHz standard.

4.27 On 'A' Channel DC the base potential of Q10 is held low by the AC/DC switch and D2. Q10 is turned off and Q13 on so that the AC amplifier is inhibited but the 'A' Channel DC amplifier is active. IC11a cuts off the 1MHz standard as before.

4.28 When CHECK is selected a '0' is applied to IC27d by the CHECK/OPERATE/HOLD switch. The resulting '1' at IC11a/1 allows the 1MHz standard to reach IC28b. A '1' is also applied to IC16e, cutting off the 'A' Channel DC amplifier at IC33b. In the inhibited state IC33b/9 is at '1', so the 1MHz standard is passed to Q4 and IC5/22. The '1' at IC27d also switches on Q5 which switches off Q10 to inhibit the 'A' Channel AC amplifier.

4.29 When CHECK is selected a '1' is applied to IC28c/10. If T.I. is also selected a '1' is applied to IC28c/9 and IC28d/13. The resulting '0' at IC28c/8 inhibits the 'B' amplifier at IC33a, and the 1MHz standard is substituted for the 'B' Channel signal. This is used to display the HOLD OFF interval selected, as described in paragraph 4.37.

SLOPE SELECTION

4.30 The polarities of the Start and Stop triggering edges are selected by switches 1S4 (STOP SLOPE) and 1S5 (START SLOPE) in conjunction with the Exclusive-OR gates IC9b and d for Stop and IC9c for Start. An Exclusive -OR gate gives a logic '1' when the inputs are dissimilar. Alternative logic levels can be applied by means of the slope selection switches, so the gates determine which edge of the input pulse shall perform the start or stop function. IC11c/9 is held at '0' when RATIO is selected irrespective of the setting of 1S5, ensuring positive edge triggering.

START INHIBIT

4.31 Start signals are inhibited by IC11d for as long as a logic '0' is applied at pin J of the Data Output socket or the Start Inhibit pin on the rear panel.

STOP CHANNEL SELECTION

4.32 Stop channel selection is made by the B-A/B-B switch in conjunction with gates IC10a, b and c and IC11b. With B-A (double line) selected a '1' is applied to IC10a/13 and a '0' (via IC11b) to IC10b/3. In all modes except TOTALIZE and RATIO IC10a/2 is at '1', so the 'A' Channel signals are passed by IC10a. In TOTALIZE and RATIO modes, however, IC10a/2 is at '0' and IC10b/3 is at '1'. The 'B' Channel signals are selected by IC10b irrespective of the setting of 1S3.

4.33 With B-B (single line) selected a '0' is applied to IC10a/13 and '1' (via IC11b) to IC10b/3. This allows 'B' Channel signals to be passed by IC10b.

4.34 The selected stop signal is applied to IC10c. In FREQUENCY, PERIOD and RATIO modes IC10c/9 is held at '0' and stop signals are inhibited. In all other modes the selected stop signal is passed to IC86, part of the Hold Off circuit described in paragraphs 4.35 to 4.39.

HOLD OFF AND HOLD OFF DISPLAY

4.35 When in the TOTALIZE or T.I. modes the Stop signal can be inhibited by means of the Hold Off timer IC15. In all other modes IC15 is held in the reset state by a '0' at pin 4 derived from the Function switch bank and Q7. IC15/3 is at '0', and Stop signals are passed by the NOR gate consisting of IC8b and f to the differentiating circuit C24/R40 and the Stop driver Q11.

4.36 With TOTALIZE or T.I. selected, but the Hold Off control in the OFF (switched) position IC15 remains in the reset condition since IC15/4 is connected to ground via R33.

4.37 When the Hold Off control is moved away from the switched position +5V is applied to D3 and R32. IC15/4 is held at '0' by IC8e except when the main gate is open. When the main gate is opened by the Start signal the front edge of the gate pulse, differentiated by C21/R34, turns off Q8. The resulting pulse, inverted by IC16b, triggers IC15. IC15/3 goes high for the duration of the Hold Off interval, and IC8a holds the Stop input, IC5/21, at '0'. The timer is reset at the end of the main gate open period by the '0' applied to IC15/4 by IC8c.

4.38 The duration of the Hold Off interval is controlled by varying resistance of 1R3. When the potentiometer is not in the OFF (switched) position LP11 is on.

4.39 The duration of the Hold Off interval can be displayed by selecting CHECK and T.I. Under these conditions IC28a/8 is at '0', which inhibits the 'B' Channel amplifier at IC33a. The 1MHz standard is fed into the start system via IC11a, IC16f, IC28d and IC28e. This starts measurement of the Hold Off time interval. At the end of the Hold Off time interval IC8a releases the Stop input IC5/21, and the next 1MHz pulse terminates the measurement. The measured time interval is then displayed.

MANUAL START AND STOP

4.40 The start and stop drivers, Q9 and Q11, have their emitters connected to ground via the snap action transistor switch Q12/Q31 and R100. Under normal conditions C16 is charged and Q12 and Q31 are on. Pressing 1S50 discharges C16 rapidly, turning the transistors off. This inserts R100 in the emitter supply of Q9 and Q11, producing simultaneous signals at the Start and Stop inputs of IC5.

DATA OUTPUT AND DISPLAY

4.41 Details of the data output format are given in the Supplementary Data section of the Technical Specification at the front of the book.

4.42 The Display Assembly contains a 7-digit readout system using l.e.d. seven segment numerical indicators. The display data is fed from IC5 on pins 15 to 18 to the BCD to 7 segment decoder IC25. The four way output is fed from a parallel to serial (multiplex) system with IC5, which reads each store in succession for 100μs under the control of a 10kHz signal derived from the frequency standard.

4.43 The decoded data is presented to the numerical indicators in parallel. The 10kHz signal from IC5/7 is counted in IC18, the BCD count being decoded to decimal in IC21. In states 0 to 6 of IC18 the numerical indicators are enabled in turn.

4.44 A pulse R(0) is generated in IC5 during the reading of the 10^0 store. This is used to set IC18 to state 0 at the time of 10^0 store readout to ensure that each store content is displayed in the correct position.

Decimal Point Decoding

4.45 The decimal point information is fed out of IC5 during state 9 of IC21. In state 9 a '0' is fed from IC21/11 to IC13/4 and 13. The decimal point information is entered into IC13, which is then latched.

4.46 During states 0 to 6 the information latched into IC13 is compared with the BCD count from IC18. When the two sets of information match the outputs of the gates IC19b, c and d will all be '0'. This gives a '1' at the base of the decimal point driver Q29 and the appropriate decimal point is turned on.

Overflow

4.47 If the 10^6 counter overflows a pulse is present at IC5/16 during state 8 of IC21. This pulse is fed to IC12a/2 and its inverse to IC12d/12. The outputs of these gates are normally at '0', but during state 8 a '0' occurs at IC21/10. This is fed to IC12a/3 and IC12d/13 which reverses the state of the latch IC12b and c and lights LP1.

Gate Indicator

4.48 The main gate waveform is inverted by IC22e. When the main gate is open the D14/R121 junction is at '1' and Q36 is on. LP3 therefore lights in synchronism with the main gate waveform.

Units Indicators

4.49 The units indicators LP4,5,6 and 7 are controlled by IC27a,b and c, IC30b,c and d and IC6d. They light to indicate the units in which the display should be read according to the combination of Function and Time Base switches selected.

DISPLAY TIME AND RESET GENERATOR

Introduction

4.50 This circuit is centred on IC29a, IC29b and transistors Q33, Q34 and Q35,and Q39. It produces a display time of approximately 150 milliseconds which is extended to approximately 1.5 seconds in Time Interval, Time Interval Average and Totalize. At the end of the display time a negative-going transition at IC5/13 resets the counter.

Display Time Circuit

4.51 The main gate signal at IC5/19 is applied via IC9a to the control bistable at IC29b/11. At the end of the main gate period IC29b/11 goes high, sending IC29b/9 high. This removes the clamp from the display time capacitor C58 and allows it to charge up via R119, R118, Q33 (see next para.) and switch IS2 (CHECK and OPERATE positions).

4.52 Q33 is turned off by a '1' supplied to the base via IC8d from an earth on R70 when the FREQ., PERIOD and RATIO switches are not selected. This adds R117 to the charging circuit which increases the display time to about 1.5 seconds.

4.53 Capacitor C58 charges until the voltage at Q34 emitter rises above that at the base (fixed by R125/R122) at which point Q34 begins to conduct and a regenerative action develops which allows C58 to discharge very rapidly through R120 and Q34/Q35. The time taken for this discharge determines the width of the reset pulse, which should be not less than 100 ns.

Reset Pulse and Hold State

4.54 When the regenerative switch Q34/35 fires, the voltage at Q35 collector falls sharply. This negative-going pulse is fed to IC29b/13 and clears the control bistable. The transition at IC29b/8 is fed via IC26c to reset the counter by a '1' to '0' transition at IC5/13. This signal also blanks the display via Q32 and IC20f for a brief period while the counter is preparing for a new measurement. When switch 1S2 is set to HOLD the +5V supply is disconnected and capacitor C58 cannot charge up, thus preventing any reset action. An external HOLD logic '0' applied at the DATA OUTPUT socket pin 6 will close gate IC26c and prevent the counter resetting.

Manual Reset

4.55 The manual reset is controlled by IC29a. Pressing S51 puts a '0' on IC29a/1, giving a '0' at IC29a/5. This gives a '1' at IC26c/8 which is applied to IC5/13, preventing automatic resetting. At the same time the '0' from S51 is passed via IC22a and IC22b to IC29b/13, holding the Display Time Generator ready to start a new timing period.

4.56 Release of S51 allows the 10kHz clock signal at IC29a/3 to drive IC29a/5 (Q) to the '1' state, providing a reset signal at IC5/13. At the same time IC29a/6 transition from '1' to '0', differentiated by R113/R114/C57, drives IC5/4 low to unlatch and clear the data stores.

External Reset

4.57 An external reset signal with a minimum duration of 5 ms can be applied via pin 7 of the rear data connector. This reset is applied to IC29a/1 and operates in the same way as manual reset (see previous paragraphs).

Segment Check

4.58 This is obtained by selecting CHECK and holding down the manual reset button. In CHECK position the switch 1S2 (via IC27d) applies a '1' to enable IC26a. Depressing the manual reset switch S51 applies a '1' (via IC22a) to IC26a/1 and 2. The resultant '0' at IC25/3 produces an 'all-eights' display while the manual reset button is held down.

FREQUENCY STANDARD

Oscillator Assembly 11-1254

4.59 This is a discrete component 5MHz oscillator which is attached to the rear panel. Access to the trimming capacitor (C4) is provided by an aperture in the rear panel. The components are mounted on a printed circuit board, Racal-Dana part number 19-0834, the circuit of which is shown in the main p.c.b. circuit (Fig.4) and in Fig.2.

Precision Oscillators

4.60 Two fast warm up oscillators from the Racal-Dana Instruments range, models 9442 and 9421, are available. Model 9421 cannot be fitted if the Battery Pack option is fitted. If Model 9421 is fitted a link must be fitted to the B7G base as shown in Fig.4.

4.61 Both oscillators are precision units. If a fault develops users are advised to return the oscillator to Racal-Dana Instruments or their agents for servicing. No parts list or circuit information is provided in this handbook.

Frequency Doubler

4.62 The 5MHz from the oscillator is fed via C67 to a shaper formed by IC2d and L2. The square wave signal is then fed via IC2a to the monostables IC3a and IC3b. A positive monostable pulse is produced from each edge of the input and fed from IC3a/4 and IC3b/12 respectively to the Nand gate IC2c, thus producing a 10MHz input to the CDI Chip at IC5 pin 5.

1 MHz Standard Output

4.63 The 1MHz standard is fed from IC5/6 via the buffer IC2b to the 1MHz BNC output socket on the rear panel.

External Standard Input

4.64 For use in the Frequency and Period modes a 1MHz standard can be fed in via the 'B' input socket. The input path is via the 'B' channel amplifier and the Start gates to Q9 and thence to the input of the CDI Chip at IC5/20.

4.65 If an external standard is connected to the 'B' Channel and is operating, IC31a will be preset and clocked as described in paragraph 4.23 and LP8 will flash. In the Frequency and Period modes IC30 is enabled by a '1' at IC30a/1. The waveform at IC31a/6 is applied to IC30a/2 so that LP10 lights in synchronism with this waveform. Since the time IC31a is in the preset state is very short LP10 appears to be on continuously. It is a feature of the CDI chip that it will automatically select an external standard if present at IC5/20 in preference to the internal standard at IC5/5.

4.66 It should be noted that the application of a logic '0' at the Start Inhibit or pin J of the Data Output socket will inhibit the external standard signals. The instrument will revert to internal frequency standard even though LP10 remains lit and LP8 continues to flash.

POWER SUPPLY

Introduction

4.67 The power supply circuit operates from a.c. line supply or from optional internal batteries, and provides the following facilities:-

(1) +5V and -5V stabilized supply rails.

(2) Trickle charging and full-rate charging of batteries, if fitted.

(3) Standby indication and indication of low battery voltage.

(4) Battery economy operation.

Also on the main p.c.b. is a subsidiary circuit, a +2V stabilizer Q20/Q21, which supplies the CDI Chip.

Line Power

4.68 With the LINE POWER/CHARGE/BATTERY POWER switch at LINE POWER the supply is fed in via a 3-pin fixed plug on the rear panel, thence via S53, the anti-surge fuse FS50 and S54 to the transformer T50. The transformer tappings and S54 position are arranged to suit the local supply voltage as shown in Fig.5.1 in Chapter 5. The output at secondary winding 'A' is rectified to provide +5V by the potted bridge rectifier D50, which is mounted on the rear panel for adequate heat dissipation.

4.69 The -5V supply is provided by the discrete diode bridge D22-D25 with fuse protection on the negative rail at FS1 (this fuse must be a normal quick action type).

+5V Switching

4.70 The +5V supply to the instruments is switched by the NORMAL/STANDBY switch S52 or the series transistor switch Q50 which is mounted on the main frame. Normally Q50 is in the cut off condition, but with S52 at NORMAL, Q50 is bypassed via the contacts of S51 and current can pass to the +5V rail. When S52 is at STANDBY the bypass is removed and the +5V rail is cut off.

Standby Indicator LP1

4.71 The OVERFLOW indicator also serves as a STANDBY indicator. The anode of LP1 is connected via p.c.b. pin 8 to the emitter of Q50, and thus receives +5V even though the main +5V rail is cut off. The current in LP1 has a path to earth via 1R17 which lights the l.e.d. When full +5V power is restored, however, this path is closed and LP1 is extinguished.

+5V Stabilization

4.72 When S53 is switched to ON the switch contact S53b connects the anode of zener diode D20 to the unsmoothed negative side of rectifier D50. This turns on Q43.

4.73 When Q43 conducts it turns on Q44 which draws current through the reference zener diode D21. A reference voltage on potentiometer R159 is applied to the non-inverting input of the comparator IC7a/2 and is compared with the voltage from the 0V rail at IC7a/1. Any discrepancy produces an output at IC7a/12 which, via Q40, regulates the current in Q51. Instructions for setting up R159 are given in Chapter 5.

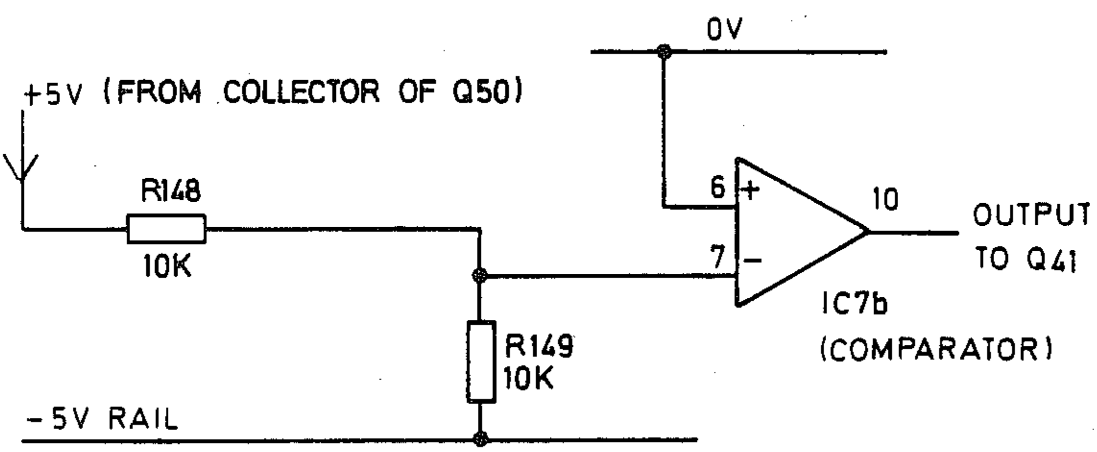
-5V Stabilization

4.74 The reference for the -5V rail is derived from the stabilized +5V at the collector of Q50, the comparison being made in the comparator IC7b, with regulation by Q52.

4.75 Fig.4.1. shows the basic connections to the input comparator IC7b.

4.76 Provided the voltage on the -5V rail is equal on the +5V rail, IC7b/7 will be at 0V. This is compared with the reference 0V at IC7b/6. A voltage difference will generate an output at IC7b/10 which will drive Q41 to regulate the current in the series transistor Q52.

NOTE: Transistor Q42 applies only to battery operation. (See para.4.82).



-5V Stabilizer Fig. 4.1

Battery Economy Operation

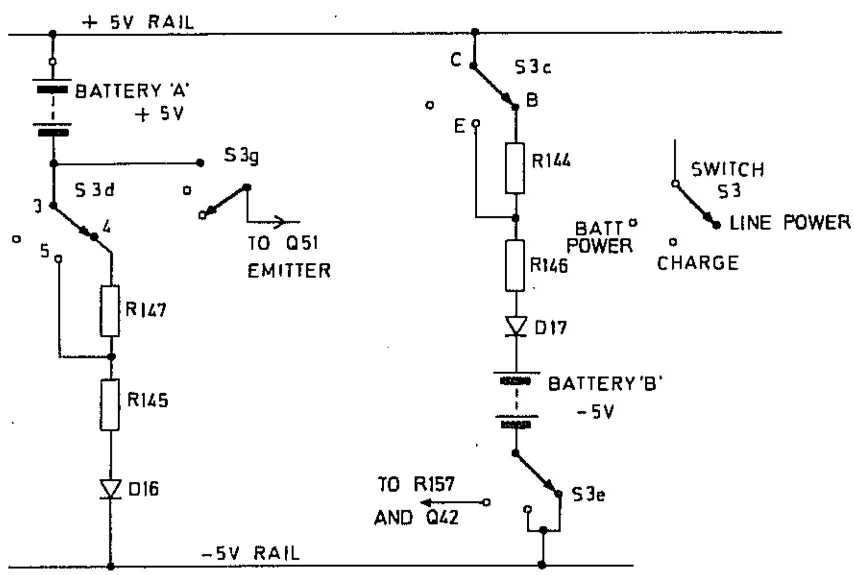
4.77 When the NORMAL/STANDBY switch is at STANDBY the +5V supply rail is cut off because Q50 is non-conducting. If the RESET switch S5.1 is depressed, an earth is applied via D15 to the junction of R141/C69. This rapidly discharges C69 causing the output of IC4a/10 to change from negative to positive. This turns on Q38 which feeds current into Q50 base, thus turning on the +5V supply to the instrument.

4.78 Q50 will conduct until C69 has recharged, which takes approximately one minute. The +5V rail then reverts to the standby condition with Q50 cut off. This arrangement operates with either mains or battery power supply, but its purpose is battery economy. It may be noted that the frequency standard is in continuous operation while on STANDBY.

Battery Charging

4.79 Batteries (if fitted) are trickle charged whenever the instrument is operating from the mains supply. For charging, each battery is connected between the +5V and -5V power rails, as shown in Fig.4.2. The diodes D16 and D17 prevent discharge of the batteries if the mains supply is disconnected with the instrument switched on.

4.80 For full rate charging the switch bypasses R147 and R144 which increases the current by approximately ten times.



Battery Charging Circuit Fig.4.2

Charge Indicator LP3

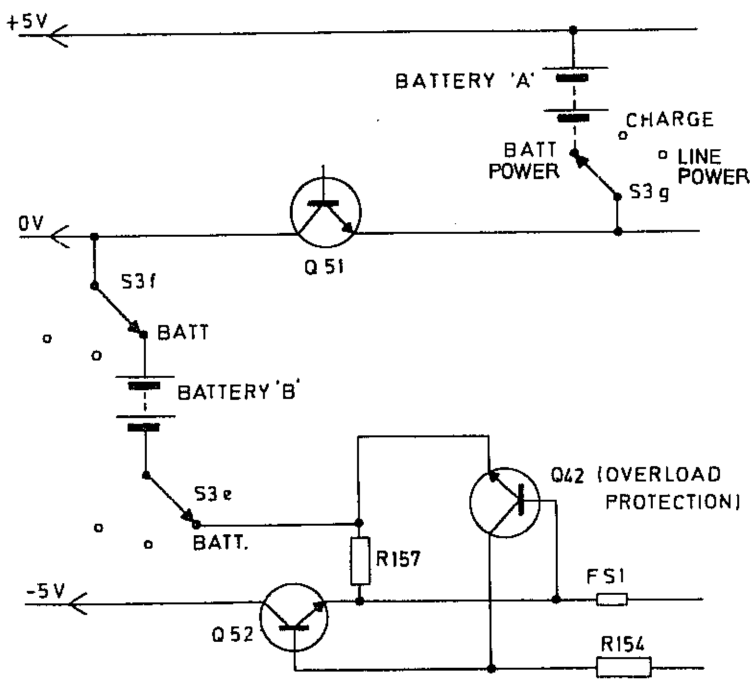
4.81 The indicator LP3 lights when switch S3 is in the CHARGE position, thus indicating that power is available to the charging circuit. The anode of LP3 is connected to the stabilized +5V rail at the collector of Q50. The same +5V supply from Q50 turns on Q36 via R121 which lights LP3.

Battery Powered Operation

4.82 When switch S3 is set to the BATTERY POWER position the contacts S3c and S3d disconnect the charging paths. The negative side of battery 'A' is connected via contact S3g to Q51 emitter. (See Fig.4.3.).

4.83 The 0V rail at Q51 collector is connected via contact S3f to the positive side of battery 'B'. The negative side of battery 'B' is connected via the low resistance R157 to Q52 emitter.

4.84 Transistor Q42 provides overload protection to the negative battery. In the event of an overload, Q42 will turn on, thus shunting the base current away from Q52 and closing down the regulator.



Battery Power System Fig. 4.3

Battery Low Indicator LP2

4.85 The Battery Low indicator lights when the volt drop across the series regulator Q51 falls to less then 0.5V (approx.). The sensing component is IC4b.

4.86 Resistors R151 and R153 are connected from the +5V rail through the POWER switch S53b to the emitter of Q51. The junction of R151/R153 is connected to the non-inverting input at IC4b/2. The inverting input IC4b/1 is connected direct to the collector of Q51. Provided the voltage at Q51 collector is more than about 0.5V positive relative to the emitter there will be no output from IC4b and LP2 will not light. If the lamp comes on it indicates that only a few minutes of battery life are remaining and recharging is essential.

Over Discharge Protection

4.87 The Battery Low indicator informs the user that the batteries are in need of re-charging. If this warning is disregarded the instrument will shut itself off after a few minutes to prevent over-discharge of the batteries. This is arranged by Q43 and D20.

4.78 R152 and D20 are connected across Battery 'A' (via S53b and S3g). If the voltage falls below about 5V, Q43 will start to turn off which will cause Q44 to turn off. Reference diode D21 will become ineffective, thereby removing the reference voltage. The voltage of the positive rail will fall and the instrument will cease to draw current.

CDI Chip Stabilized Supply

4.89 The +2V stabilized supply for IC5 is derived from the +5V line and regulated by Q20/Q21, using a reference voltage from within the Chip. The +5V supply to this circuit is via link LK2 in the standard instrument, or via link LK3 when the ovened oscillator is fitted. The change of linking is to maintain correct battery loading.

CHAPTER 5

MAINTENANCE

TABLE 5: Test Equipment Required

Item	Preferred Item	Remarks
1	Multimeter Danameter 2000A	AC range 0 to 250 volts. DC range 0 to 10 volts, 20kΩ/volt Ohms range 150Ω mid scale.
2	Oscilloscope BWD525	Bandwidth d.c. to 50MHz Y Sensitivity 50mV/cm.
3	Frequency Standard	1MHz accurate to ± 1 part in 10^8 Output 1 volt r.m.s. nominal.
4	Signal Generator Racal-Dana 9061/9062/9063 combination	Frequency range 8Hz to 60MHz. Output level from 5mV to 1V r.m.s. into 50Ω The LF signal generator must have a signal to noise ratio better than 40dB.
5	Pulse Generator	Pulse width from 100 ns to 1ms 1kHz to 1MHz p.r.f. Amplitude from 50mV to 3V. Output impedance 50Ω.
6	BNC 'T' Pieces	50Ω quantity 2 required.
7	BNC Terminating Pad	50Ω
8	Coaxial leads	BNC to BNC connectors, 50Ω 1 metre long, quantity 2. 15cm long, quantity 1.
9	Variac	To supply 125mA at outputs from 188 volts to 235 volts or 250 mA at outputs from 94 volts to 118 volts.
10	DC Supply	A 3 volt battery is suitable.

REMOVAL OF COVERS

WARNING: DANGEROUS AC VOLTAGES ARE EXPOSED WHEN COVERS ARE REMOVED WITH AC SUPPLY CONNECTED.

5.1 (1) Set the POWER switch to 'off', switch off the a.c. supply at the supply point and unplug the power lead.

(2) Remove the rubber plugs (located near to the rear end) from both side panels of the instrument and slacken, by about two turns, the screws revealed.

(3) Grip the rear panel assembly and ease it back from the main case to the maximum extent available (about 5 mm).

(4) The rear edge of either cover can now be lifted and the cover withdrawn outwards and rearwards.

(5) To replace the covers reverse the above procedure.

TRANSFORMER VOLTAGE SELECTION

5.2 Ensure the voltage range selected is suitable for the local supply. To check the selection proceed as follows:

(1) Unplug the power cable from the supply and remove the top cover (see paragraph 5.1).

(2) Refer to Fig.5.1 and note the diagram which corresponds to the local supply voltage.

(3) Connect the link and the wires from S5.4 to the transformer tappings as shown in the appropriate diagram.

(4) Set S54 to the correct half of the selected range.

(5) Ensure that the rear panel label correctly indicates the voltage range selected.

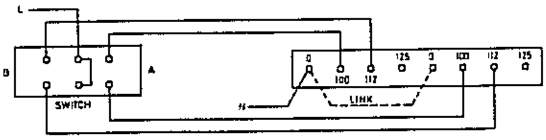
(6) Replace the top cover.

FUSES

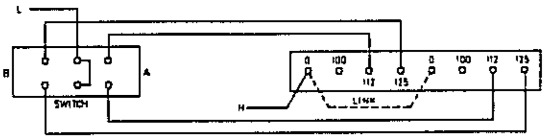
5.3 Check that the power fuse on the rear panel is correctly rated for the supply voltage, as follows. The fuse is a glass cartridge type, 5 x 20 mm.

Supply Range	Fuse Rating	Racal-Dana Part No.
188V to 265V	125mA anti-surge	23-0031
94V to 132V	250mA anti-surge	23-0043

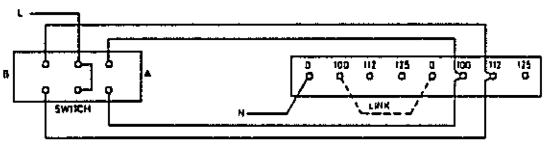
94-106V (SWITCH TO A)
106-119V (SWITCH TO B)



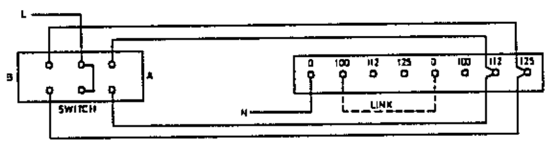
106-119V (SWITCH TO A)
118-132V (SWITCH TO B)



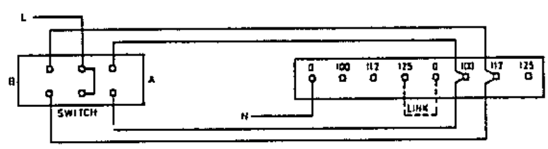
188-212V (SWITCH TO A)
200-225V (SWITCH TO B)



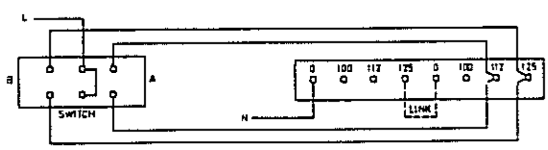
200-225V (SWITCH TO A)
212-238V (SWITCH TO B)



212-238V (SWITCH TO A)
224-251V (SWITCH TO B)



224-251V (SWITCH TO A)
235-255V (SWITCH TO B)



WDH8155

Line Voltage Selection Fig.5.1

POWER LEAD

5.4 Fit a suitable plug to the power lead in accordance with the standard colour code:-

	European	American
LINE	Brown	Black
NEUTRAL	Blue	White
EARTH (GROUND)	Green/Yellow	Green

A.C POWER SUPPLIES CHECK

Resistance Check

5.5 With the power lead disconnected check the resistance of the transformer primary circuit (including FS50) using the multimeter (Table 5, item 1). The resistance should be as shown in Table 6.

TABLE 6

Power Supply Resistance Measurement

Voltage Selected	S52 Position	
	LO	HI
94-106/106-119	35Ω ± 6Ω	39Ω ± 7Ω
106-119/118-132	39Ω ± 7Ω	44Ω ± 7Ω
188-212/200-225	122Ω ± 18Ω	130Ω ± 20Ω
200-225/212-238	130Ω ± 20Ω	138Ω ± 20Ω
212-238/224-251	138Ω ± 20Ω	145Ω ± 22Ω
224-251/235-265	145Ω ± 22Ω	153Ω ± 22Ω

Supply Rail Voltages

5.6 (1) Remove the covers and prepare the power supply as described in the preceding paragraphs. Check that the a.c. supply voltage is correct.

(2) Set the power source selector switch on the rear panel to LINE POWER.

(3) With power supply connected, switch POWER to ON.

(4) Using the multimeter (Table 5, item 1) check the d.c. voltages at the following points on the main p.c.b. (Fig. 3 at the back of the book shows the component layout).

Test Point	Measurement		Remarks
TP 13	+ 5.0V ± 0.1V	)	Relative to chassis (TP12)
TP 14	-5.1V ± 0.2V	)	

NOTE: The supply rails can be adjusted simultaneously by means of R159. If the limits given above cannot be achieved check that the transformer primary connections and position of S52 agree with the local supply voltage. If these are correct the zener diode D21 should be checked.

Ripple Level

5.7 Connect the variac (Table 5, item 9) to the local a.c. supply, and power the unit under test (UUT) from the variac. Monitor the variac output with the multimeter (Table 5, item 1), and adjust to give the minimum voltage of the range which suits the local supply.

5.8 Using the oscilloscope (Table 5, item 2) monitor TP13 and TP14, using a.c. coupling. The power supply 100Hz ripple should be less than 150mV peak to peak.

BATTERY POWER SUPPLIES CHECK

Charging Rate Checks

5.9 The charging rate can be checked only when the battery pack is fitted. It can be checked by inserting a multimeter, set to an appropriate current range, in series with the battery lead, or by measuring the volt drop across a charge path resistor and calculating the current. The latter method is recommended. Measurement is made with a.c. supplies connected and the POWER switch ON.

LETHAL VOLTAGES ARE EXPOSED.

5.10 For the A Battery, (+ 5 volts), voltage measurement should be made across the 3.9Ω resistor R145. This is accessible from the top of the main p.c.b. The more negative end is towards the rear panel.

5.11 For the B Battery, (-5 volts), voltage measurement should be made across the 39Ω resistor R146. This is mounted on the top of the main p.c.b., but because of the proximity of other components measurement can be made more easily from the underside. The more positive end is that closest to the LINE POWER/CHARGE/BATTERY POWER switch.

5.12 Measurements should be made across both resistors with the rear panel switch in both the LINE POWER and CHARGE positions to allow calculation of the trickle charge and full charge rates respectively. The charging current varies considerably according to the state of charge. Nominal values during the middle of the charge period are:

		Current	Voltage across R145
Battery A	Trickle charge	85 mA	0.33V
	Full charge	670 mA	2.61V

		Current	Voltage across R146
Battery B	Trickle charge	5 mA	0.19V
	Full charge	55 mA	2.15V

Battery Economy Check

5.13 This check can be carried out without the battery pack fitted. Set the UUT controls as follows:

(1) Power source selector on the rear panel to LINE POWER

(2) NORMAL/STANDBY switch to STANDBY

(3) POWER switch to ON. After approximately a minute the display should blank out and the OVERFLOW/STANDBY indicator should light.

5.14 Press and release the RESET button. The display should indicate all zeros and the OVERFLOW/STANDBY indicator should be extinguished. After approximately one minute the display should again blank out and the OVERFLOW/STANDBY indicator should light.

PERFORMANCE TESTS AND CALIBRATION

NOTE: The procedures detailed in the following paragraphs may be carried out using line or battery supplies (provided the battery pack option is fitted). If battery supplies are to be used for performance testing it is desirable that the batteries be in the fully charged state at the commencement of testing. No test result obtained when the Battery Low indicator is lit should be considered valid.

Segment, Decimal Point and Self Check

5.15 (1) Set the POWER switch to ON and the STANDBY/NORMAL switch to NORMAL.

(2) Set the CHECK/OPERATE/HOLD switch to CHECK.

(3) Depress the FREQ.A button and verify that the GATE/CHARGING indicator lights.

(4) Select Time Base (n) = 1.

(5) The instrument should now read 0001000.kHz/ms. Refer to Table 7 and check the display and decimal points (Frequency column) for each time base button.

(6) Depress the PERIOD 'A' button and verify the readout and decimal points according to the Period column of Table 7.

(7) Briefly hold in the RESET button and check that the display reads 'all eights' (segment check).

TABLE 7

Self Check Readout

Range 'n' Selected	Gate Time	Display ± 1 count	
		Frequency	Period
1	1ms	0001000. kHz/μs	0000001.kHs/μs
10^1	10ms	001000.0 kHz/μs	000001.0 kHz/μs
10^2	100ms	01000.00 kHz/μs	00001.00 kHs/μs
10^3	1sec	1000.000 kHz/μs	0001.000 kHz/μs
10^4	10sec	* 000.0000 kHz/μs	001.0000 kHz/μs
10^5	100sec	* 00.00000 kHz/μs	01.00000 kHz/μs
		* Overflow lamp will light after 10 seconds on 10^4 Time Base and 100 seconds on 10^5 Time Base.	

A.C. Sensitivity Check: Input A

5.16 Equipment required:

Item	Table 5 Item No.
Signal Generator	4
Coaxial lead	8
T piece	6
BNC terminating pad	7

5.17 Connect the T piece to the Input 'A' socket of the UUT. Using the coaxial lead connect the signal generator to the T piece. Terminate the open end of the T piece with the 50Ω pad.

5.18 Set the controls on the UUT as follows:

(1) 'A' Channel AC/DC switch to AC.

(2) CHECK/OPERATE/HOLD switch to OPERATE.

(3) SENSITIVITY control to the 10 mV click position.

(4) Time base (n) 1 selected.

(5) FREQ. A selected.

5.19 Apply a frequency of 55 MHz at a level of 20 mV r.m.s. to the UUT. Adjust R44 to the mid point of the range over which counting is steady. Apply the frequencies shown in Table 8 at a level of 8 mV r.m.s., changing the time base selection as indicated. Verify that the display reads correctly and is stable.

TABLE 8

Input 'A' Sensitivity Check

Frequency	Time Base	Display
55 MHz	1	0055000. kHz/μs
13 MHz	1	0013000. kHz/μs
100 kHz	10^2	00100.00 kHz/μs
1 kHz	10^2	00001.00 kHz/μs
10 Hz	10^3	0000.010 kHz/μs

NOTE: If repairs involving the stage containing IC32 have been made and the above specification cannot be achieved a 33pF capacitor, Racal-Dana part number 21-1514, should be fitted in position C7 and the test repeated.

5.20 Select Time Base (n) 1 and apply 13 MHz at a level of 10 mV r.m.s. With the SENSITIVITY control in the 10 mV position ensure the display is stable. Increase the signal generator output to 500 mV r.m.s. and rotate the SENSITIVITY control clockwise. Check that counting ceases before the fully clockwise position is reached.

Totalize Check

5.21 Equipment required:

Item	Table 5 Item No.
Signal Generator	4
Coaxial leads	8
T piece	6
BNC terminating pad	7

5.22 Connect the T piece to the 'A' Channel input of the UUT. Connect the signal generator to the T piece and terminate the open end of the T piece with the 50Ω pad.

5.23 Set the controls of the UUT as follows:

(1) AC/DC switch to AC.

(2) CHECK/OPERATE/HOLD switch to OPERATE.

(3) SENSITIVITY control fully anti clockwise (to click position).

(4) Time Base (n) 10^5 selected.

(5) Total $\frac{A}{n}$ selected.

5.24 Apply a frequency of 100 kHz at a level of 10 mV r.m.s. from the signal generator. Press and release the START/STOP button and check that the least significant digit counts from 0 to 9 in approximately 10 seconds. Increase the frequency to 1 MHz to check the second digit, and select Time Base (n) 10^4 to 1 in turn to check the more significant digits.

5.25 Check that when the display has counted to all nines the OVERFLOW indicator lights, but counting continues. Press and release the START/STOP button, and check that counting stops and that the display is held for approximately 1.5 seconds before resetting automatically.

5.26 Set the CHECK/OPERATE/HOLD switch to HOLD. Start and stop a new measurement cycle using the START/STOP button, and ensure that the display does not automatically reset after 1.5 seconds, but is held until the RESET button is pressed and released.

DC Amplifier and Attenuator Checks

5.27 Equipment required:

Item	Table 5 Item No.
Signal Generator	4
Coaxial leads (1x 1 metre, 1 x 15cm)	8
T piece (2)	6
BNC terminating pad	7
Oscilloscope	2

5.28 Connect a T piece to both the 'A' and 'B' Channel inputs. Connect the T pieces together with the short coaxial lead and connect the signal generator and the 50Ω pad to the T pieces. Connect the oscilloscope to monitor the output at the Marker Output pins on the rear panel (1 MHz at approximately 3 volts peak to peak).

5.29 Set the UUT controls as follows:

(1) AC/DC switch to DC.

(2) Both TRIGGER LEVEL controls fully anticlockwise (to click position).

(3) Both attenuators to X1.

(4) FREQ.A selected.

5.30 Apply 1 MHz at a level of 10 mV r.m.s. Increase the input level slowly, noting the level at which each Trigger Indicator commences to flash. This should be less than 80 mV r.m.s. in both cases. Check that the marker outputs are present when the indicators flash.

5.31 Put the attenuator switches to X10, and repeat the test. The Trigger indicators should flash with an input level less than 800 mV r.m.s.

5.32 Calculate the true attenuation for each channel. This should be 20 dB ± 3 dB.

Ratio Check

5.33 Equipment required:

Item	Table 5 Item No.
Signal Generator	4
Coaxial leads (1 x 1 metre, 1 x 15 cm)	8
T piece (2)	6
BNC terminating pad	7

5.34 Connect a T piece to both 'A' and 'B' Channel inputs. Connect the T pieces together with the short coaxial lead, and connect the signal generator and the 50Ω pad to the T pieces.

5.35 Set the UUT controls as follows:

(1) AC/DC switch to DC.

(2) Both attenuators to X1.

(3) Both TRIGGER LEVEL controls fully anticlockwise (to click position).

(4) CHECK/OPERATE/HOLD switch to OPERATE.

(5) Ratio $n\frac{A}{B}$ selected.

(6) Time Base (n) 1 selected.

5.36 Apply a 10 MHz signal at 80 mV r.m.s. Check that the display reads 0000001 and that no decimal points or units indicators are on.

5.37 Select Time Base (n) 10^1 to 10^5 in turn and check that the display increases by a factor of 10 for each change.

Time Interval, Single Line Check

5.38 Equipment required:

Item	Table 5 Item No.
Pulse Generator	5
Coaxial lead (1 x 1 metre)	8
T piece	6
BNC terminating pad	7

5.39 Connect the T piece to the 'B' Channel input of the UUT. Connect the pulse generator to the T piece and terminate the open end of the T piece with the 50Ω pad.

5.40 Set the controls of the UUT as follows:

(1) CHECK/OPERATE/HOLD switch to OPERATE.

(2) HOLD OFF control fully anticlockwise (to OFF position).

(3) 'B' Channel attenuator to X1.

(4) Stop Channel selection switch to B.

(5) Start and Stop slope selection switches to ⎍

(6) Time Base (n) 1 selected.

(7) T.I. selected.

(8) 'B' Channel TRIGGER LEVEL control fully anticlockwise (to click position).

5.41 Set the pulse generator to 1 kHz p.r.f., 4:1 mark/space ratio and +1.25 volts peak amplitude. Select Time Base (n) 1 to 10^5 in turn and verify that the display reads as shown in Table 9.

TABLE 9

Time Interval Decimal Point Check

Time Base (n)	Display
1	001.0000 ms
10^1	0001.000 ms
10^2	00001.00 ms
10^3	000.0010 sec
10^4	0000.001 sec
10^5	00000.00 sec

NOTE: (1) The final digits of the display will depend on the accuracy of the pulse being measured. It is proof of the UUT function if the display is stable and the digits move to the right by one place for each change of n.

(2) All measurements are made to an accuracy of ±1 count, so a 1 in the right hand position for $n = 10^5$ should not be taken as evidence of UUT malfunction.

5.42 Select Time Base (n) 1. Set the Start and Stop slope switches as shown in Table 10 and verify the display obtained.

TABLE 10

Slope Selection Switch Check

Switch Setting Start	Switch Setting Stop	Display
_┌	┐_	000.8000
┐_	_┌	000.2000

NOTE: The final digits of the display will depend on the accuracy of the pulse being measured. The sum of the readings obtained should equal the reading obtained for n = 1 in paragraph 5.41.

5.43 Short the Start Inhibit pin on the rear panel to chassis and check that the Gate indicator goes off and the display reads all zeros. Remove the short circuit.

Time Interval, Double Line Check

5.44 Equipment required:

Item	Table 5 Item No.
Pulse Generator	5
Coaxial leads (1x1 metre and 1x15 cm)	8
T piece (2)	6
BNC terminating pad	7

5.45 Connect a T piece to both the 'A' and 'B' Channel inputs. Connect the T pieces together with the short coaxial lead. Connect the pulse generator to one T piece with the longer coaxial lead and terminate the open end of the other T piece with the 50Ω pad.

5.46 Set the controls of the UUT as follows:

(1) CHECK/OPERATE/HOLD switch to OPERATE.

(2) AC/DC switch to DC.

(3) Both channel attenuators to X1.

(4) Both TRIGGER LEVEL controls fully anticlockwise (to click position).

(5) Stop Channel selection switch to A.

(6) T.I. selected.

(7) Time Base (n) 1 selected.

(8) HOLD OFF Control fully anticlockwise (to OFF position).

5.47 Set the pulse generator as detailed in paragraph 5.41 and carry out the test detailed in paragraph 5.42.

5.48 Put the CHECK/OPERATE/HOLD switch to CHECK. Turn the HOLD OFF control away from the OFF position but at the anticlockwise end of its travel. Verify that the indicator lights, and that the display reads less than 0.1 ms. Turn the control fully clockwise and verify that the display reads at least 100 ms.

Time Interval (Average) Check

5.49 Equipment required:

Item	Table 5 Item No.
Pulse Generator	5
Coaxial leads (1 x 1 metre)	8
T piece	6
BNC terminating pad	7

5.50 Connect the T piece to the 'B' Channel inputs of the UUT. Connect the pulse generator to the T piece and terminate the open end of the T piece with the 50Ω pad.

5.51 Set the controls of the UUT as follows:

(1) CHECK/OPERATE/HOLD switch to OPERATE.

(2) HOLD OFF control fully anticlockwise (to OFF position).

(3) 'B' Channel attenuator to X1.

(4) 'B' Channel TRIGGER LEVEL control fully anticlockwise (to click position).

(5) Stop Channel selection switch to B.

(6) Time Base (n) 1 selected.

(7) T.I. (AVG) selected.

(8) Start slope selection switch to 

(9) Stop slope selection switch to 

5.52 Set the pulse generator to give a pulse width of 200 ns at a p.r.f. of approximately 950 kHz. (The actual p.r.f. must give a minimum interval between pulses of 150 ns and must not be harmonically related to 1 MHz). Select Time Base (n) 1 to 10^5 in turn and verify that the display reads as in Table 11.

TABLE 11

Time Interval (Average) Check

Time Base (n)	Display
1	000000.2 μs
10^1	00000.20 μs
10^2	0000.200 μs
10^3	000200.0 μs
10^4	00200.00 μs
10^5	0200.000 μs

NOTE: The final digits will depend upon the accuracy of the pulse being measured. It is proof of the UUT function if the display is stable and the digits move to the left by one place for each change of n.

DC Offset Check

5.53 Equipment required:

Item	Table 5 Item No.
D.C. Supply	10

5.54 Connect the d.c. supply to the 'A' Channel BNC input with the negative to the centre connection.

5.55 Set the controls on the UUT as follows:

(1) CHECK/OPERATE/HOLD switch to OPERATE.

(2) AC/DC switch to DC.

(3) Both attenuators to X1.

(4) Both TRIGGER LEVEL controls at mid travel.

5.56 Turn the 'A' Channel TRIGGER LEVEL control anticlockwise. The trigger l.e.d. should light when the indicator on the control is approximately in line with the - sign on the panel. Return the control to the mid position.

5.57 Reverse the d.c. supply and check that the trigger l.e.d. lights. Turn the 'A' Channel TRIGGER LEVEL control clockwise. The trigger l.e.d. should be extinguished when the indicator on the control is approximately in line with the + sign on the panel. Turn the control fully anticlockwise to the click position.

5.58 Repeat paragraphs 5.56 and 5.57 with the d.c. supply connected to the 'B' Channel BNC input and using the 'B' Channel TRIGGER LEVEL control.

External Frequency Standard Check

5.59 Equipment required:

Item	Table 5 Item No.
Oscilloscope	2
Frequency standard	3
Coaxial leads	8
T piece	6

5.60 Connect the oscilloscope Y input to the 1 MHz OUTPUT socket on the rear panel of the UUT. Connect the frequency standard to both the external trigger input of the oscilloscope and the 'B' Channel input of the UUT.

5.61 Set the oscilloscope to External Trigger, and to a time base of 1 μs/cm.

5.62 Set the controls of the UUT as follows:

(1) CHECK/OPERATE/HOLD switch to OPERATE.

(2) 'B' Channel attenuator to X1.

(3) 'B' Channel TRIGGER LEVEL fully anticlockwise (to click position).

5.63 Select each function in turn. Check that for FREQUENCY A and PERIOD A the waveform is a stationary 1 MHz, with a mark/space ratio of approximately 4:1. For all other functions the waveform should be of approximately 1:1 mark/space ratio and may drift slowly across the oscilloscope screen. The displayed waveform should be not less than 3 volts peak to peak. The EXTERNAL STANDARD indicator should light only when the FREQUENCY and PERIOD functions are selected.

Internal Frequency Standard Calibration

5.64 Equipment required:

Item	Table 5 Item No.
Oscilloscope	2
Frequency standard	3
Coaxial leads	8

5.65 Connect the oscilloscope to the 1 MHz OUTPUT socket on the rear panel of the UUT. Connect the frequency standard to the external trigger input of the oscilloscope. Set the oscilloscope to External Trigger and a time base of 1 μs/cm.

5.66 When the internal time base has been on for at least one hour check that the drift of one cycle of the waveform past a fixed point on the oscilloscope screen is within the following limits:

(1) For oscillator 11 - 1254, not less than 10 seconds (1 part in 10^7).

(2) For oscillators 9421 and 9442, not less than 100 seconds (1 part in 10^8).

5.67 The oscillator trimmer can be adjusted via a hole in the rear panel of the UUT.

Removal of Display P.C.B.

5.68 To change a component on the display board it is necessary to separate the display p.c.b. from the front panel. Complete removal of the p.c.b. from the instrument should be avoided if possible.

(1) Disconnect power and remove the upper and lower covers (see paragraph 5.1).

(2) With a flat screwdriver prise off the cap on each carrying handle boss. Remove the screws now exposed and remove the handle.

(3) Slide back the short length of metal trim at each side of the instrument into the space normally occupied by the handle boss. This will expose the two screws which secure the front panel.

(4) Unsolder two earth braids and two screened connections between the display p.c.b. and the main p.c.b. on the underside. Unsolder the R202/C103 combination on the upper side.

(5) Remove the screws securing the front panel and withdraw it as far as the wiring permits. Take care not to damage the flexible wiring connector.

(6) Remove the knobs of the 'A' and 'B' Channel DC OFFSET potentiometers and of the HOLD OFF control.

(7) Unsolder the START/STOP switch connections, the RESET switch connections and the connections to the 'A' and 'B' channel BNC sockets.

(8) Remove the lower screw of the POWER and NORMAL/STANDBY switch holder and the four other screws which secure the p.c.b. to the front panel. The p.c.b. can now be separated from the front panel.

5.69 If the p.c.b. is to be removed completely, remove the second screw in the POWER and NORMAL/STANDBY switch holder. Unsolder three wires to the 'A' Channel DC OFFSET, three wires to the 'B' Channel DC OFFSET and one wire to the HOLD OFF potentiometers. Unsolder the 40 way connector.

5.70 Replacement is carried out in the reverse order to dismantling. Care must be taken in lining up the l.e.d. indicators and switch knobs when attaching the p.c.b. to the front panel. Care must be taken in aligning S1 and S2 with the holes in the front panel when this is replaced on the instrument.

Removal of Main P.C.B.

5.71 With the top and bottom instrument covers and the battery pack removed all the main p.c.b. components are accessible for servicing, so the need for complete removal will be rare.

5.72 (1) Remove the upper and lower instrument covers as described in paragraph 5.1.

(2) Unsolder the wiring between the rear panel items and the main p.c.b. Remove the rear panel.

(3) Remove the battery pack, if fitted, (see paragraphs 5.80 and 5.81).

(4) Unsolder the connections to the three power transistors on the side frame.

(5) Disconnect the reservoir capacitors C100 and C101, noting the polarity of the leads. Withdraw the capacitors until the lugs are clear of the holes in the main p.c.b.

(6) Unsolder the R202/C103 combination on the upper side of the board and the two braids and two screened connections on the lower side of the board. Unsolder the braid from the main p.c.b. to the earthing tag under the main p.c.b. securing screw at the side of the main p.c.b.

(7) Unsolder three wires to the 'A' Channel DC OFFSET, three wires to the 'B' Channel DC OFFSET and one wire to the HOLD OFF potentiometers. Unsolder the 40 way connector.

(8) Unsolder 2 wires to the POWER switch and 2 wires to the NORMAL/STANDBY switch.

(9) Remove the 4 screws securing the main p.c.b. and withdraw it to the rear.

5.73 Replacement is carried out in the reverse order. Care must be taken to align S1 and S2 with the holes in the front panel during replacement. If the 40 way connector is damaged replace with Racal-Dana part number 25-6032. If the capacitor tie has to be cut, replace with Racal-Dana part number 24-0155.

FITTING FREQUENCY STANDARD 9421 or 9442

5.74 It should be noted that the frequency standard model 9421 cannot be fitted if the battery pack is fitted.

5.75 Remove the top cover of the instrument (see paragraph 5.1). Unsolder the three leads from the fitted frequency standard. Remove the retaining screws (and spacers in the case of the discrete component oscillator) and the black plate (if fitted). Remove the frequency standard.

5.76 Attach the replacement frequency standard to the inner face of the rear panel using the retaining screws removed in paragraph 5.75.

5.77 Solder the leads from the main p.c.b. pins 41, 39 and 40 to the frequency standard base pins 7, 1 and 4 respectively. If model 9421 has been fitted ensure pins 5 and 6 on its base are linked.

5.78 Carry out the instrument check procedure to verify satisfactory functioning, and calibrate the frequency standard as detailed in paragraphs 5.64 to 5.67.

5.79 Replace the instrument cover.

FITTING BATTERY PACK 11-1289

NOTE: The battery pack cannot be fitted if frequency standard model 9421 is fitted.

5.80 The battery pack option consists of the following items:-

Item	Racal-Dana Part Number	Quantity
Battery Pack Assembly, complete with batteries and connecting lead.	11-1274	1
Mounting bracket	11-1239	1
Locating pegs	14-1486	2
Screws M4	24-7729	4
Washers, plain, M4	24-2705	2
Washers, crinkle, M4	24-2802	4

Fitting Procedure

5.81 (1) Disconnect the a.c. supply and remove the top cover (see paragraph 5.1).

(2) Screw the two locator pegs into the threaded holes in the inner face of the right hand side member, as seen from the front of the instrument.

(3) Place the mounting bracket against the inside of the left hand side member with the large hole over the carrying handle nut. Secure it to the side member with two M4 screws and crinkle washers.

(4) Take the battery pack, with the batteries uppermost and the connecting lead to the left, and carefully place the holes in the right hand end over the locator pegs. Lower the left hand end onto the bracket, and secure it with two M4 screws fitted with both plain and crinkle washers. The crinkle washers should be immediately below the screw heads.

(5) Plug the connecting lead onto pins 48 to 51 on the main p.c.b. just to the right of the power transformer. The pins are polarized to prevent incorrect connection.

(6) Replace the top cover. Set the rear panel switch to CHARGE, connect the instrument to suitable a.c. supplies and set the POWER switch to ON.

(7) When the batteries are fully charged check the operation of the instrument on battery power.

SECTION 3

PARTS LISTS

CIRCUIT DIAGRAMS

AND

COMPONENT LAYOUTS

ORDERING OF SPARE PARTS

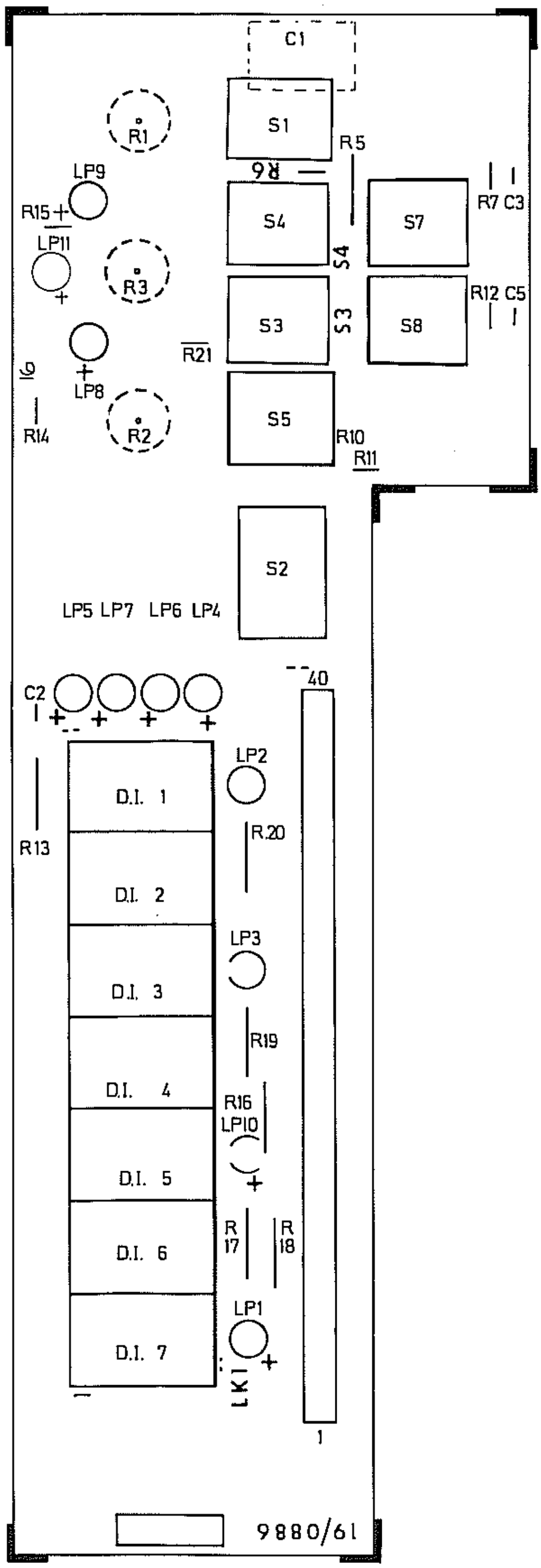
To be assured of satisfactory service when ordering replacement parts, the customer is requested to include the following information :

(a) Instrument type and serial number.

(b) The type reference of the Assembly in which the particular item is located (for example, '19-0834').

(c) The Racal-Dana Part number and circuit reference of each item being ordered.

It should be noted that a minimum charge of £10 sterling is applicable to all UK orders.



RACAL

WOH8155	19-0886
1	

Component Layout:
Display Assembly 19-0886

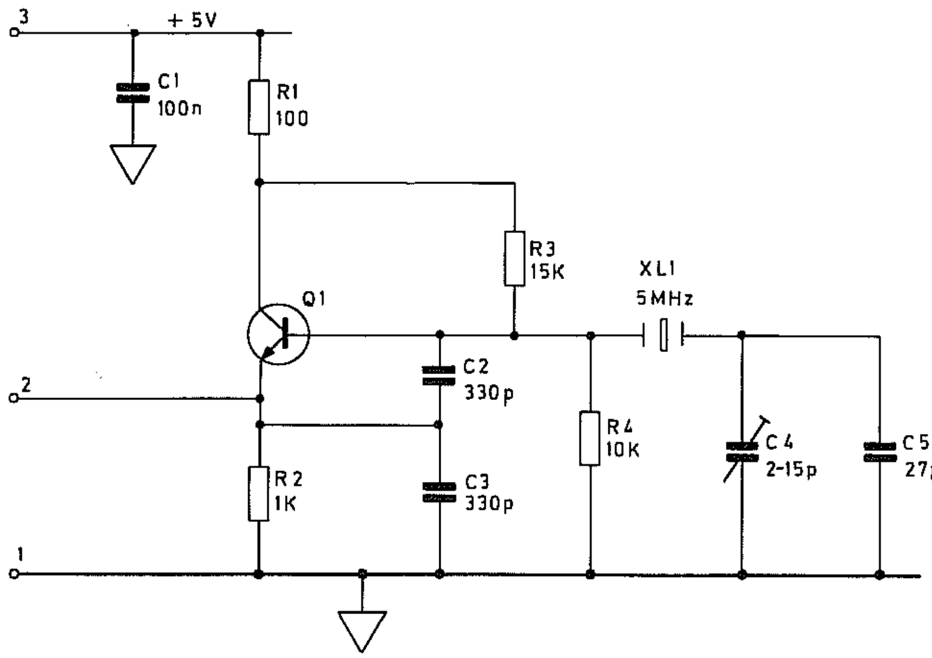
Fig. 1

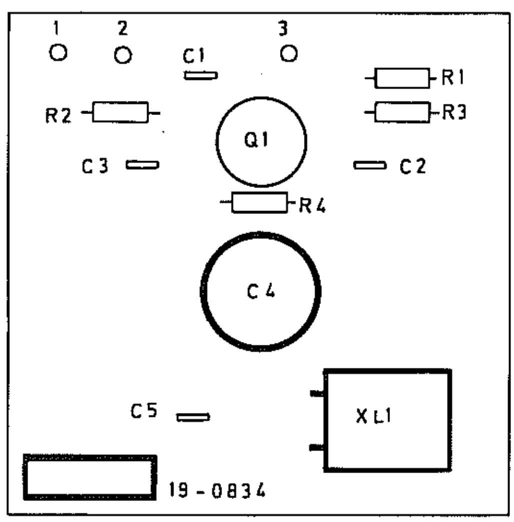
PARTS LIST

DISPLAY ASSEMBLY 19-0886

NOTE: Components are prefixed '1' on the circuit diagram (Fig. 4).

Part No.	Description	Rat	Tol %	Value	Component Reference
	Resistors	W		Ω	
20-1516	Carbon Film	0.1	5	220	R14,15
20-1517	Carbon Film	0.1	5	330	R21
20-1551	Carbon Film	0.1	5	100k	R7,12
20-1564	Carbon Film	0.1	5	120k	R6,11
20-2221	Carbon Film	$\frac{1}{4}$	5	220	R20
20-2331	Carbon Film	$\frac{1}{4}$	5	330	R13,16,18,19
20-2471	Carbon Film	$\frac{1}{4}$	5	470	R17
20-2914	Carbon Film	$\frac{1}{4}$	5	910k	R5,10
20-6625	Variable 1M log + 10k lin				R1
20-6626	Variable 1M log with switch				R3
20-6628	Variable 10k lin with switch				R2
	Capacitors	V		F	
21-1500	Ceramic	500	$\frac{1}{2}$p	2.2p	C7,8
21-1521	Ceramic	500	10	120p	C3, 5
21-1616	Ceramic	12	+80 -20	100n	C2
21-1683	Ceramic	63	2	18p	C9,10
21-4528	Polyester	400	10	47n	C1
	Switches				
23-4099	Slide switch 2 position				S1,3,4,5,7, 8
23-4100	Slide switch 3 position				S2
	Indicators				
26-1508	Numerical display, l.e.d.				D.I.1. to D.I.7
26-5004	Indicator l.e.d.				LP1,2,3,4, 5,6,7, 10,11
26-5011	Indicator l.e.d.				LP8,9
	Miscellaneous				
25-6032	Flexible Wiring, 40 way				





WOH	19-0834
1	

Circuit And Layout
5MHz Oscillator PCB 19-0834

Fig. 2

PARTS LIST

5 MHz CRYSTAL OSCILLATOR ASSEMBLY (19-0834)

Part No.	Description	Rat	Tol %	Value	Component Reference
	Resistors	W		Ω	
20-2101	Carbon Film	1/4	5	100	R1
20-2102	Carbon Film	1/4	5	1k	R2
20-2103	Carbon Film	1/4	5	10k	R4
20-2153	Carbon Film	1/4	5	15k	R3
	Capacitors	V		F	
21-1616	Ceramic	12	20	100n	C1
21-2621	Silver Mica	125	5	27p	C5
21-2631	Silver Mica	125	5	330p	C2,3
21-6030	Trimmer			2-15p	C4
	Transistors				
22-6017	Silicon NPN (2N2369)				Q1
	Crystal				
17-2087	Crystal Assembly, 5 MHz				XL1

PARTS LIST

CHASSIS, FRONT AND REAR PANELS

Part No.	Description	Rat.	Tol %	Value	Component Reference
CHASSIS ASSEMBLY 11-1297					
21-0575	Capacitor, Electrolytic	16V		4700μF	C100
21-0576	Capacitor, Electrolytic	25V		2200μF	C101
22-6081	Transistor, npn (MJE 520)				Q51, 52
22-6139	Transistor, pnp (MJE 371)				Q50
FRONT PANEL ASSEMBLY 11-1301					
20-4658	Resistor, Metal Oxide	1W	5	100kΩ	R202
21-1520	Capacitor, Ceramic	500V	10	100pF	C103
23-3030	Socket, BNC				SK50, 51
17-0113	Switch				S53, S52
23-4013	Switch				S50, 51
REAR PANEL ASSEMBLY 11-1302					
11-1254	Oscillator Assembly (refer to Parts List 2)				
17-4056	Transformer				T50
22-1650	Bridge Rectifier (VS 248) 200V, 2A				D50
23-0031	Fuselink (94V to 132V) 250mA anti-surge				FS50
23-0043	Fuselink (188V to 265V) 125mA anti-surge				FS50
23-0044	Fuse Holder for FS50				
23-3005	Socket, BNC				SK52
23-3222	Power Input Filter/Connector				
23-4091	Switch				S52
24-3515	Barb, Feedthrough				

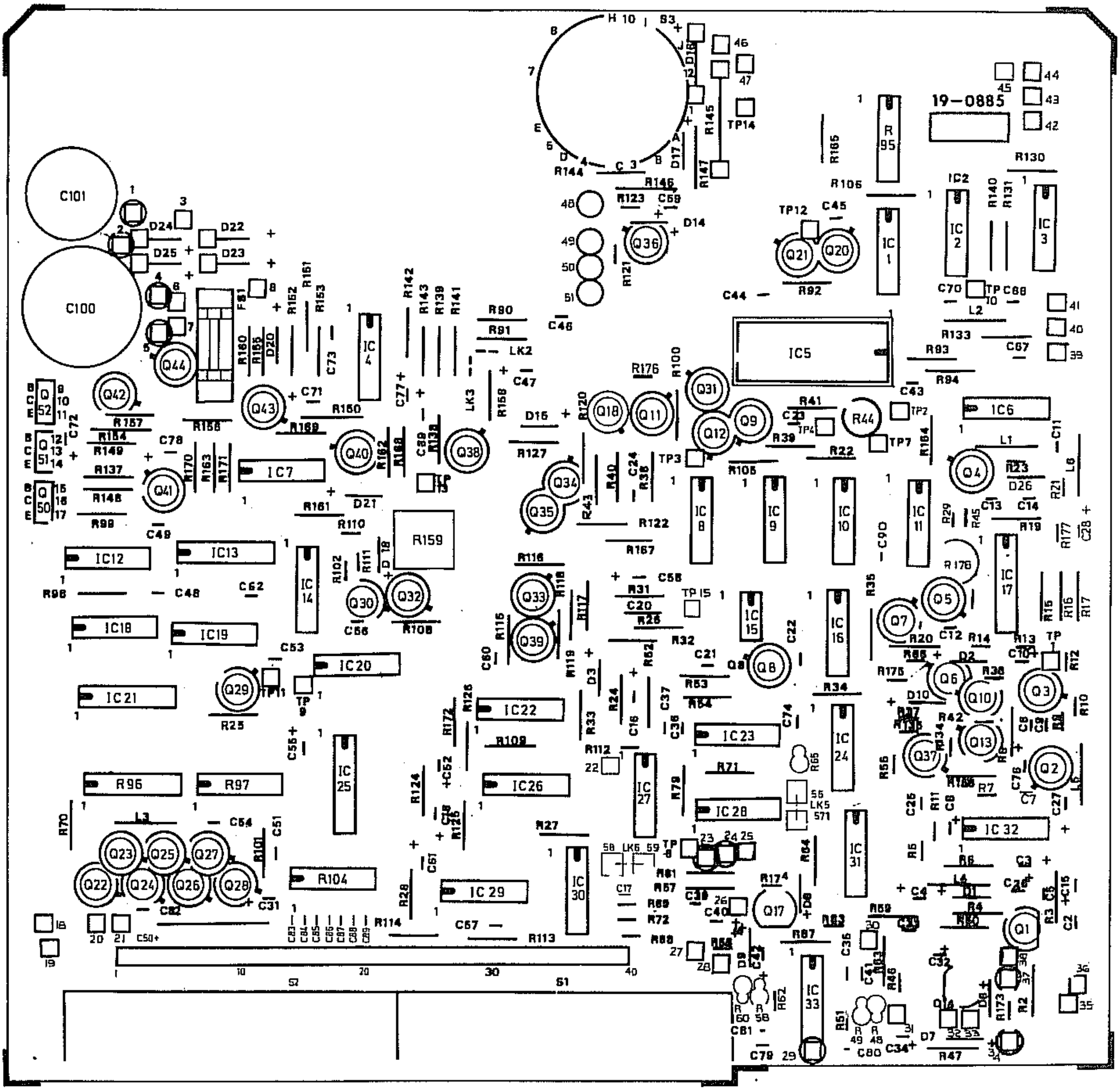
MAIN PCB ASSEMBLY 19-0885

Part No.	Description	Rat	Tol %	Value	Component Reference
	Resistors	W		Ω	
20-1514	Carbon Film	0.1	5	100	R7
20-1516	Carbon Film	0.1	5	220	R23
20-1520	Carbon Film	0.1	5	10	R83
20-1521	Carbon Film	0.1	5	1k	R5,9,11,13,18,176
20-1528	Carbon Film	0.1	5	2.2k	R14
20-1532	Carbon Film	0.1	5	470	R12
20-1533	Carbon Film	0.1	5	5.6k	R55
20-1537	Carbon Film	0.1	5	3.3k	R37,66,121
20-1538	Carbon Film	0.1	5	10k	R10,29,36,42 45,68, 69,72,102,111, 112,134,135,175
20-1542	Carbon Film	0.1	5	4.7k	R21,123
20-1546	Carbon Film	0.1	5	56	R173,174
20-1563	Carbon Film	0.1	5	22k	R110
20-1565	Carbon Film	0.1	5	560k	R46,56
20-2006	Carbon Film	¼	5	3.3	R157
20-2100	Carbon Film	¼	5	10	R59,63,87,119
20-2101	Carbon Film	¼	5	100	R106,120,137, 172
20-2102	Carbon Film	¼	5	1k	R6,17,27,33,35, 41,108,124,133,138, 155
20-2103	Carbon Film	¼	5	10k	R20,25,26,28,34 70,71,92,93,105, 109,113,114,126, 131,139,156,160, 164,167
20-2104	Carbon Film	¼	5	100k	R54
20-2105	Carbon Film	¼	5	1M	R50,61
20-2106	Carbon Film	¼	10	10M	R2
20-2120	Carbon Film	¼	5	12	R3
20-2121	Carbon Film	¼	5	120	R165
20-2150	Carbon Film	¼	5	15	R90,91
20-2151	Carbon Film	¼	5	150	R98,99
20-2152	Carbon Film	¼	5	1.5k	R161
20-2155	Carbon Film	¼	10	1.5M	R141
20-2182	Carbon Film	¼	5	1.8k	R162
20-2220	Carbon Film	¼	5	22	R168,170
20-2222	Carbon Film	¼	5	2.2k	R4,171
20-2272	Carbon Film	¼	5	2.7k	R127
20-2274	Carbon Film	¼	5	270k	R53
20-2331	Carbon Film	¼	5	330	R31, 32, 100
20-2332	Carbon Film	¼	5	3.3k	R122,125,142
20-2333	Carbon Film	¼	5	33k	R158
20-2391	Carbon Film	¼	5	390	R144
20-2392	Carbon Film	¼	5	3.9k	R115,116
20-2393	Carbon Film	¼	5	39k	R118
20-2394	Carbon Film	¼	5	390k	R117
20-2470	Carbon Film	¼	5	47	R8
20-2471	Carbon Film	¼	5	470	R22,38,43,94,163,166
20-2472	Carbon Film	¼	5	4.7k	R39,40,64,169
20-2473	Carbon Film	¼	5	47k	R151
20-2474	Carbon Film	¼	5	470k	R52
20-2560	Carbon Film	¼	5	56	R24
20-2561	Carbon Film	¼	5	560	R19
20-2562	Carbon Film	¼	5	5.6k	R65,79,130, 140,153
20-2681	Carbon Film	¼	5	680	R152
20-2682	Carbon Film	¼	5	6.8k	R143
20-2820	Carbon Film	¼	5	82	R101
20-2821	Carbon Film	¼	5	820	R15,16
20-2914	Carbon Film	¼	5	910k	R47,57
20-3151	Metal Oxide	½	5	150	R154
20-3270	Metal Oxide	½	5	27	R147
20-1529	Carbon Film	0.1	5	33	R177
20-1575	Carbon Film	0.1	5	18k	R51,62

Part No.	Description	Rat	Tol %	Value	Component Reference
		W		Ω	
20-3390	Metal Oxide	½	5	39	R146
20-3820	Metal Oxide	½	5	82	R150
20-4033	Metal Oxide	¼	1	10k	R148,149
20-4037	Metal Oxide	¼	1	1.8k	R48,49,58,60
20-5055	Wirewound	2.5		3.9	R145
20-5500	D.I.L. Array 7 x 56				R104
20-5501	D.I.L. Array 8 x 220				R96
20-5502	D.I.L. Array 13 x 1k				R97
20-5503	D.I.L. Array 13 x 10k				R95
20-7071	Variable, linear	¼	20	10k	R159
20-7025	Variable			200	R44,178
	Capacitors	V		F	
21-0609	Electrolytic	6.3	-10+50	470μ	C50
21-1000	Tantalum	35	20	3.3μ	C16,58,59
21-1038	Tantalum	6.3	20	47μ	C3,8,15,18,26, 27,28,31,32,34 40,42,47,55,61, 69,71,72,77,78
21-1039	Tantalum	16	20	22μ	C4,10,76
21-1048	Tantalum	35	20	2.2μ	C52
21-1513	Ceramic	500	10	27p	C70
21-1514	Ceramic	500	10	33p	C7, 13
21-1516	Ceramic	500	10	47p	C24
21-1518	Ceramic	500	10	68p	C23
21-1520	Ceramic	500	10	100p	C14
21-1524	Ceramic	500	10	220p	C9
21-1532	Ceramic	500	20	1n	C36,45,48,49, 57,67
21-1534	Ceramic	500	20	1.5n	C21
21-1537	Ceramic	500	20	2.7n	C53
21-1545	Ceramic	25	+80-20	10n	C22
21-1589	Ceramic	10	+80-20	220n	C44
21-1616	Ceramic	12	+80-20	100n	C2,5,6,11,12, 17,25,33,35,37, 39,41,43,46,51, 54,56,60, 62,68, 73,74,79,82
21-1671	Ceramic	63	0.25p	1.8p	C80,81
21-4507	Polyester	100	20	150n	C20
21-1610	Ceramic	100	+80-20	10n	C83,84,85,86, 87,88,89
21-1688	Ceramic	63	2	47p	C90
	Diodes				
22-1029	Silicon, general purpose (1N4149)				D1,3,6,7,8, 9,14,15,17,18,
22-1602	Silicon (1N4002)				D16,22,23,24,25
22-1807	Voltage reg. (BZX79C4V7)				D20
22-1810	Voltage reg. (BZX79C6V2)				D10,21
22-1811	Voltage reg. (BZX79C6V8)				D2
22-1033	Hot Carrier (5082.2811)				D26

Part No.	Description	Rat	Tol %	Value	Component Reference
	Integrated Circuits				
22-4044	Quad 2-Input Pos. NAND Gate (7400)				IC2
22-4053	Triple 3 Input Pos. NAND Gate (7410)				IC26
22-4061	Hex. Inverter Open Collector O/P (7405)				IC8
22-4128	BCD to 7-Segment Decoder (74247)				IC25
22-4202	Dual Freq. Compensated Op. Amp. (747)				IC4, 7
22-4206	Precision Timer (72555P)				IC15
22-4221	Differential Video Amp. (Selected 733)				IC32
22-4228	Dual Voltage Comparator (NE521)				IC33
22-4505	Schottky Quad 2-Input NAND Gate (74SN00N)				IC28
22-4516	Schottky Dual D-Type Bistable (74S74N)				IC31
22-4528	Triple Line Receiver (MC10116P)				IC17
22-4531	Schottky Quad 2 Input NAND Gate (74LS00N)				IC11,30
22-4532	Schottky Quad 2 Input NOR Gate (74LS02N)				IC12
22-4533	Schottky Hex. Inverter (74LS04N)				IC1,16
22-4534	Schottky Dual D Type Bistable (74LS74)				IC29
22-4536	Schottky Decade Counter (74LS90)				IC18
22-4537	Dual Retriggerable Monostable (74123N)				IC3
22-4546	Schottky Quad 2 Input NAND Gate (74LS03N)				IC24,27
22-4553	Schottky Hex. Inverter (74LS05N)				IC14,22
22-4556	Schottky BCD to Decimal Decoder Driver (74LS145N)				IC21
22-4124	Schottky Triple 3 Input NAND Gate (74S10)				IC10
22-4563	Schottky Quad Latch (74LS75)				IC13
22-4566	Schottky Quad 2 Input Exclusive OR Gate (74LS86)				IC9, 19
22-4568	Schottky Quad 2 Input AND Gate (74LS08)				IC6
22-4601	CDI LSI (Racal-Dana)				IC5
22-4715	Hex. Inverter (CD4069)				IC23
22-4551	Hex. Schmitt Inverter (7414)				IC20

Part No.	Description	Rat	Tol %	Value	Component Reference
	Transistors				
22-6010	Silicon, pnp (2N4126)				Q3
22-6041	Silicon, npn (BC109)				Q10,13,32,44
22-6079	Silicon, npn (ZTX313L)				Q2,4,5,7,8,9,11 12,18,29,30,35, 36,37,38,39,42,
22-6101	FET, N Channel (W300A)				Q1
22-6112	Silicon, npn (ZTX450)				Q6
22-6113	Silicon, pnp (ZTX550)				Q20,22,23,24, 25,26,27,28, 33,34,40,41,43
22-6132	Dual N-Channel FET				Q14,17,
22-6018	Silicon, npn (MPS3640)				Q31
	Inductors				
23-7007	Inductor			0.68µH	L1
23-7014	Inductor			10µH	L6
23-7016	Inductor			22µH	L3
23-7055	Inductor			68µH	L5
23-7056	Inductor			100µH	L2,4
	Switches				
23-4078	Switch bank				S1,2
17-0084	3-Position rotary, edge				S3
	Miscellaneous				
23-0006	Fuselink, 1A				FS1
23-0034	Fuseholder (p.c.b.) for FS1				
23-3213	IC Holder for IC5				



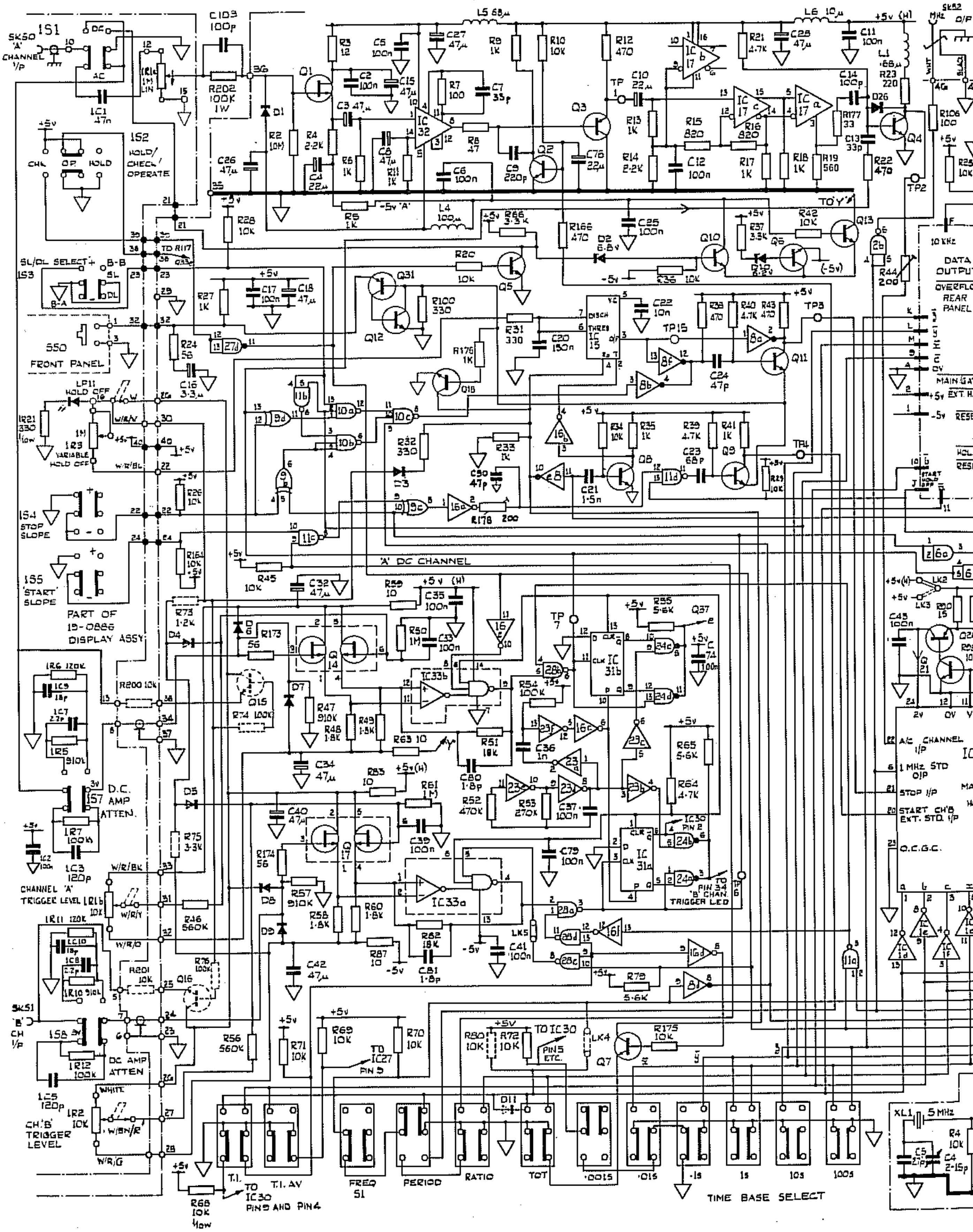
Component Layout:

Main P.C.B. Assembly 19-0885

Fig. 3

RACAL

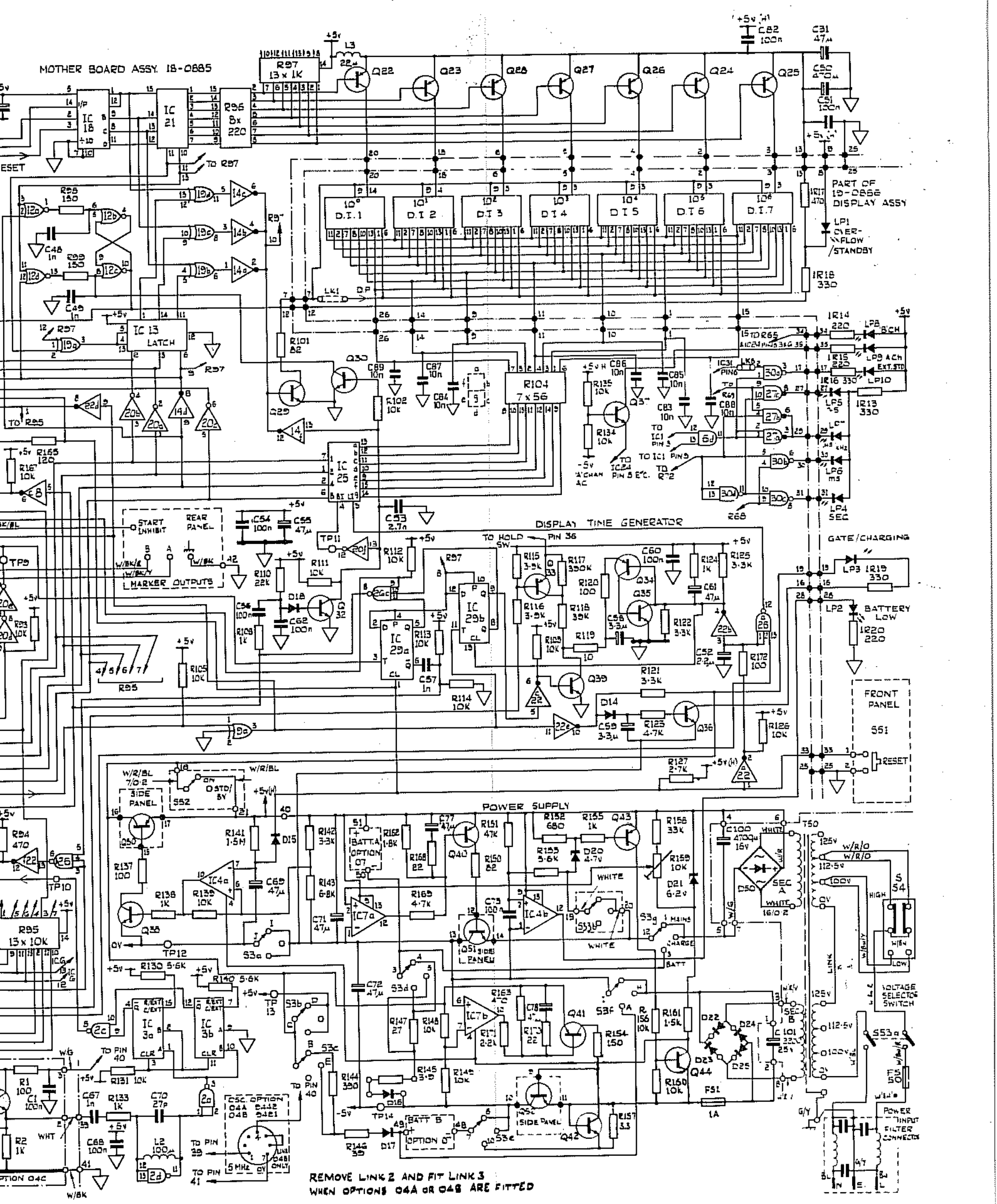
WOH8155	19-0885
1 5 6 7 8	



RACAL

WOH 8155

1 2 4 5 7 8 9



Overall Circuit: 9904 Fig.4

SECTION 4

APPENDICES

AND

CHANGE INFORMATION

OPTION 01

SERIAL TO PARALLEL INTERFACE UNIT

CONTENTS

TABLES

SERIAL TO PARALLEL INTERFACE UNIT

OPTION 01

INTRODUCTION

1. The interface comprises a metal box, measuring approximately 132 x 95 x 36mm containing the p.c.b assembly 19-0851. Connections are made to printer or data display via a 50-way fixed socket and to the '99' instrument via a flying lead fitted with a 28-way edge connector. The unit is designed to operate with the following Racal counters, referred to in this description as the '99' series'

Frequency Meters		Universal Counter Timers (UCT)	
9910	9911	9900	9901
9912	9913	9902	9903
9914	9915	9904	9905
9916	9917	9906	
9917A	9919	9908	

2. Definition of Terms

(1) Hold Signal : a signal returned by the users equipment to the interface for control purposes.

(2) Print Command : a signal output by the interface to indicate that new measurement information is available.

(3) Print Hold input : An input which allows the user's Hold Signal to prevent the parallel information from changing.

(4) Hold/Reset input : An input which allows the user's signal to prevent the parallel information from changing and which resets the instrument when the Hold Signal returns to its normal state, thus starting a new measurement.

(5) Hold Control : An input to the interface which determines the mode of operation.

FUNCTION

3. The function of the Interface Unit is to convert the serial b.c.d. data output from a '99 series' counter to a static parallel form, suitable for driving a printer, data display or processing equipment.

4. The parallel output data is updated at the end of each gate time unless the printer (or other data processing equipment) is applying a Hold Signal. In addition to measurement data the interface also transfers information on decimal point position, selected range (gate time) and the 'overflow' state of the counter display. Information supplied is for 8 digits (excluding decimal point data) on all units except the 9917 and 1197A which supply information for 9 digits.

5. Fig. A1. shows the sequence of events which occurs at the end of the gate time. Note that when using counters 9910, 9911, 9912 and 9919, and when using counter 9908 on 'A' channel with AC coupling, all timings are doubled, except the print command pulse width.

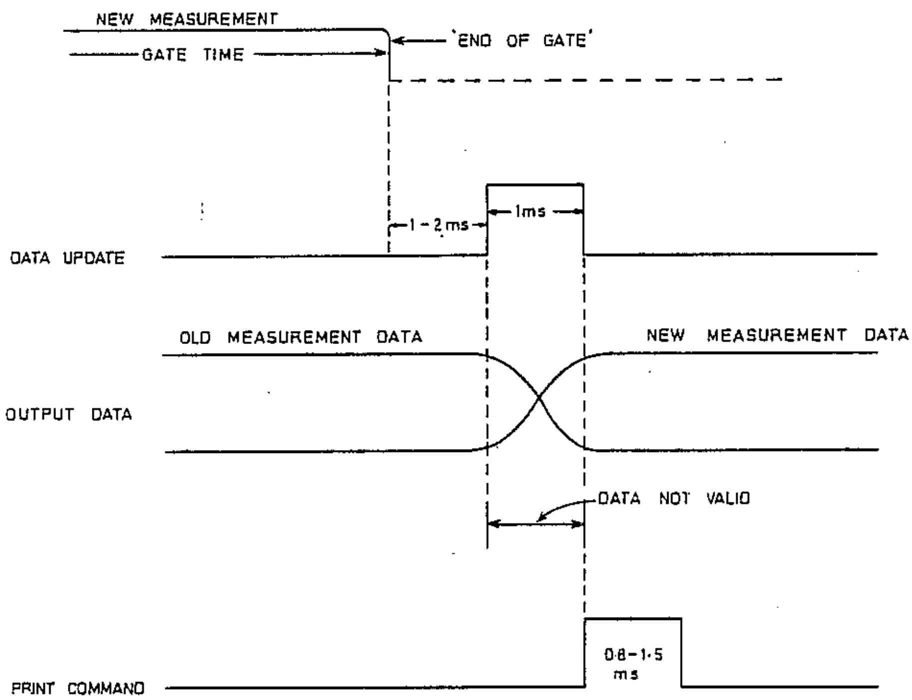


Fig. A1

CONNECTION

6. Before connecting the Interface Unit to the counter refer to the modes of operation in paras 8 to 18 and make the necessary changes to the 50-way connection or 28-way flying lead, according to the type of counter in use and the required function. All changes on the 50-way connection should be made at the customers connector.

7. Having checked the appropriate connection changes in paras 8 to 18, the interface should be connected up as follows:-

(1) Remove the black plate which covers the DATA OUTPUT aperture on the rear panel of the counter. Retain the two screws.

(2) Slacken off the cable clamp on the metal cover on the cable of the flying lead, and push the cover away from the connector.

(3) Plug the flying lead connector into the Data Output edge connector in the counter, noting the keyway which ensures correct orientation.

(4) To minimise r.f. radiation interference, the metal cover on the cables
(4) should be placed over the edge connector and held into place by the two screws which originally secured the cover plate removed in (1). The cable clamp should then be tightened.

(5) Connect the interface unit to the data processing equipment via the fixed 50-way socket.

MODES OF OPERATION

REMOTE DISPLAYS

Connections

8. If the interface is required to drive a remote display, or such other equipment that does not require the data to be held for a period longer than the gate time, check the following pin conditions on the 50-way connector:-

Pin No.	Required Connection
19	Must be either open circuit
24	or connected to OV.
49	

Latched Operation

9. The display is latched and is updated at the end of each gate time, irrespective of the counter function.

Unlatched Operation

10. (1) If the interface Unit is connected to a genuine remote display the subjective result is that the display will appear to follow the counter , for both latched and unlatched counter modes.

(2) The data outputs will be updated every 3 to 4 ms.

(3) The blue wire 'H' on the 28-way flying lead connector should be disconnected and reconnected to 'F' together with the violet wire. For other applications refer to paras 16 to 18.

USING EQUIPMENT WHICH PROVIDES HOLD SIGNALS

11. Differing instructions apply, depending on whether the counter is a frequency meter or universal counter timer (UCT) as described in paras 12 to 15.

Frequency Meters - Normal Use

12. (1) Check the following pin connections on the 50 way connector:-

Pin No.	Required Connection
19 and 24	Open Circuit, or connected to OV
49	Connected to the Hold signal

(2) The Hold signal (logic level '1' to hold) should be applied to the interface after receiving the Print Command signal, but before the end of the next gate time (ie 7 ms for 10 ms gate time), and should remain at logic level '1' for the period that the information on the data output is required to remain unchanged. Although the outputs from the interface will remain unchanged whilst a Hold is applied, the counter continues its normal measurement sequence, i.e. 'free run'. This has the advantage that the next Print Command will be given at the end of the gate time immediately following the release of the Print Hold. This result in a more rapid measurement sequence. From Fig. A2. it can be seen that a Print Command signal occurs 3 to 4 ms after an end of gate, by which time the gate time for a new measurement will have commenced.

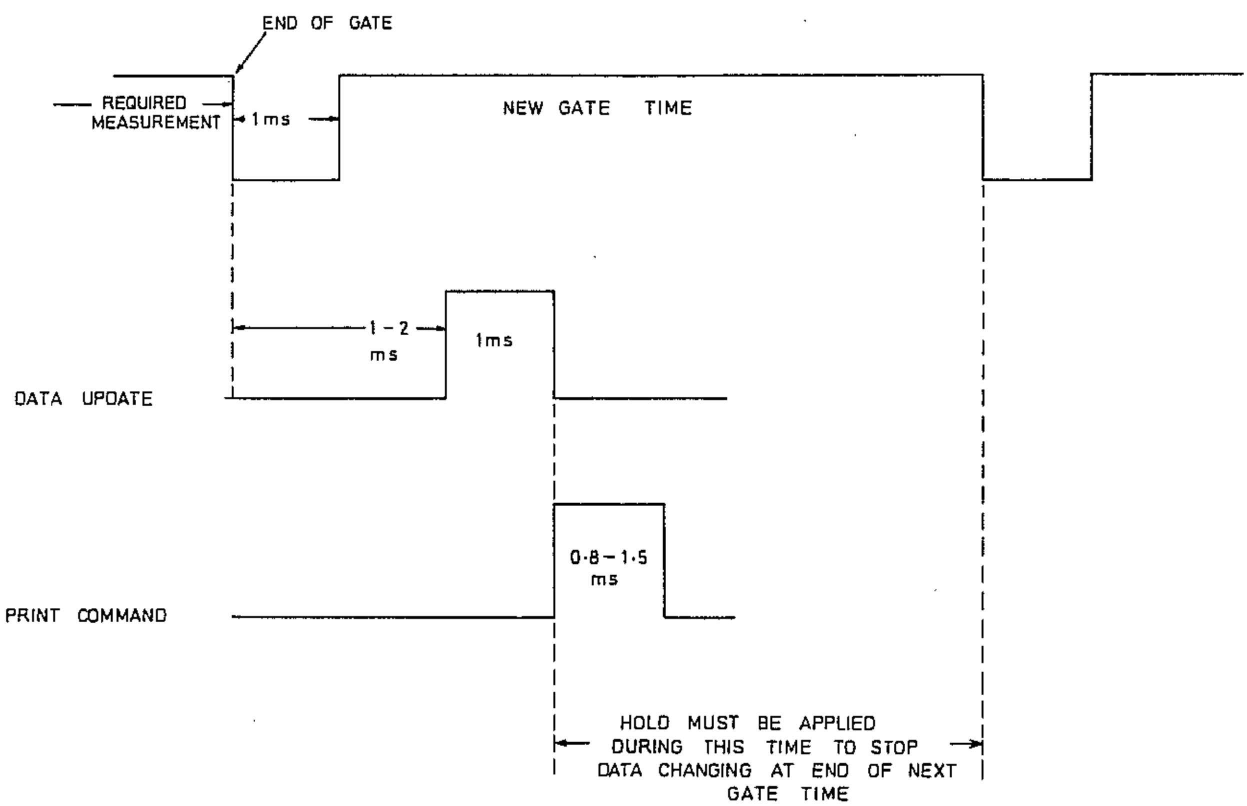


Fig. A2

13. The measurement cycle of the 99 series of UCT's has two distinct phases; the Gate Time during which the measurement is made, and the Display Time during which the results are displayed. If the hold time required by the equipment to which the interface is connected is less than the display time, the remainder of the display time is effectively wasted. The interface can be used to shorten the display time, but in so doing the counter display is reset, which may not be convenient. For this reason the interface can be used with UCT's in two modes, the Print Hold and the Hold/Reset modes, as described in paras 14 and 15. It should be noted that, with UCT's, the interface will not produce a data change or Print Command signal from the operation of a front panel RESET control.

UCT's Using Print Hold Mode

14. In the Hold/Reset mode the Hold signal extends the display time indefinitely the next gate time commencing when the Hold is released or when the normal display period has ended, whichever period is the longer. The Hold signal must be applied within the display time period in order to halt the measurement cycle. The required pin connections on the 50 way connector are as follows:-

Pin No.	Required Connection
Pin 19	Connected to Pin 50 (or to 5V via 180Ω)
Pin 49	Connected to the Hold signal source
Pin 24	To be open circuit or connected to OV

UCT's Using Hold/Reset Mode

15. In the Hold/Reset mode the Hold signal (minimum width 5 ms) extends the display time indefinitely, but when it is released the counter display resets and a new measurement commences. This result in a more rapid measurement sequence, again the Hold signal must be applied within the display time period in order to halt the measurement cycle. The required pin connections on the 50-way connector are as follows:-

Pin No.	Required Connection
Pin 19	Connected to pin 50 (or to 5V via 180Ω)
Pin 24	Connected to the Hold signal source
Pin 49	To be open circuit or connected to OV

SPECIAL APPLICATIONS

Remote Display-Special Applications

16. When used in the unlatched mode with certain types of equipment other than remote displays (for example a digital comparator) there is a limit to the maximum possible counting rate. Therefore the reading for which the comparator is looking could be missed, i.e. there is a maximum update rate for the option of 3-4 ms. This corresponds to an input frequency of 200 Hz (N=1) on Totalize mode and a maximum resolution of 10ms on Time Interval mode. The counting rate can be increased if a degree of overshoot can be tolerated.

The maximum overshoot that will occur is given by:-

$$\text{Counting Rate} \times 4 \times 10^{-3} \text{ counts.}$$

It is advisable to use the Print Command as a 'data valid' signal in such systems.

Frequency Meters - Special Applications

17. In some applications it is not possible to use the interface in the manner described in Para 12. For example, in control systems, where the output of the interface is used as feedback to the device on the input of the counter, problems arise because the next gate time has already started before the information becomes available from the previous one. Therefore, even if the feedback correction is made almost instantly, the reading at the end of the next gate time will be incorrect. Alternatively, if the correction process takes more than one gate time, the end of gate time immediately following the process will also give incorrect results. These problems may be overcome by applying a Hold signal to the Print Hold input (pin 49) for the length of time that the correction takes, plus an additional time to ensure that the gate time from which the next data is to be taken cannot start until the correction process has been completed, as shown in Fig. A3.

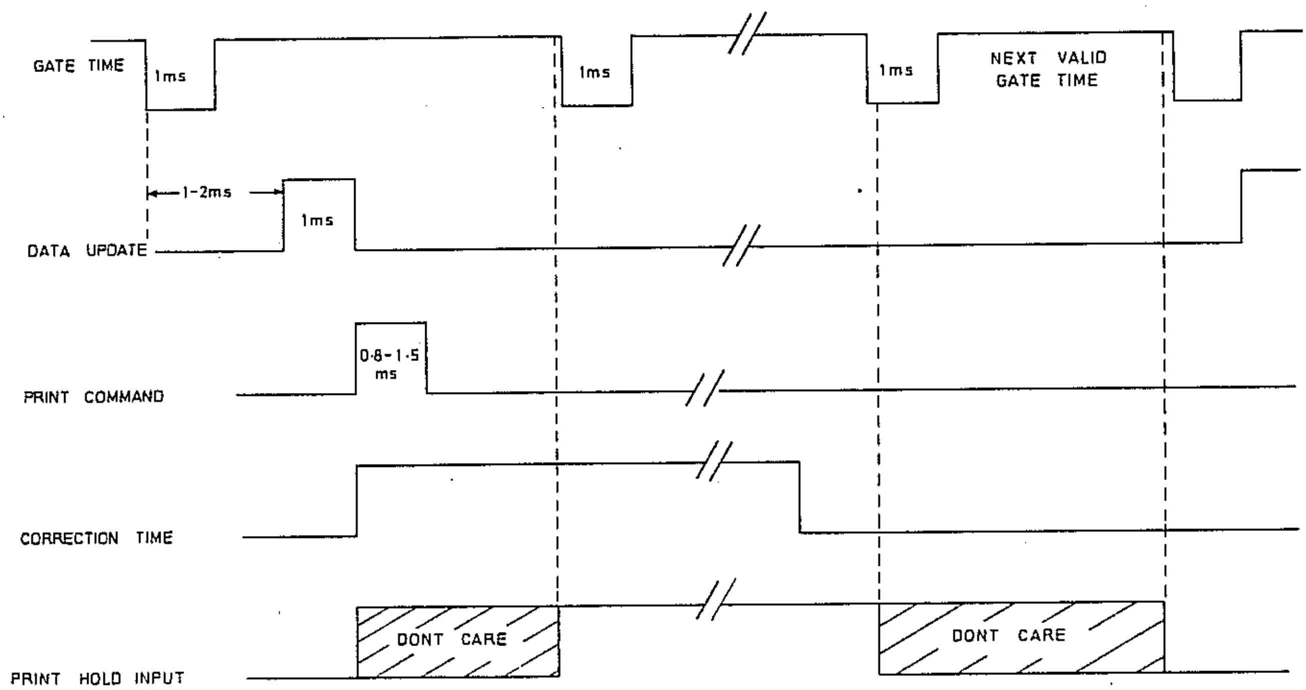


Fig. A3

18. An alternative to para 17, particularly when fast cycle times are desired, is to connect the Hold signal to the Hold/Reset input. If this is done, a stretched version must additionally be applied to the print Hold input (pin 49). The Hold signal should be at least as long as the correction process, and the signal applied to the Print Hold input should be approximately 200μs longer than that applied to the Hold/Reset input. This is to prevent the interface responding to the end of gate time produced by the reset. For cases where the correction time is short (less than the Print Command pulse width) this may be implemented by linking the Print Command output (pin 48) to the Hold/Reset input (pin 24) and by applying a stretched version of the Print Command to the Print Command to the Print Hold input (pin 49). In this way cycle times as short as 'Gate Time + 5ms' can be achieved. This is illustrated in Fig. A4.

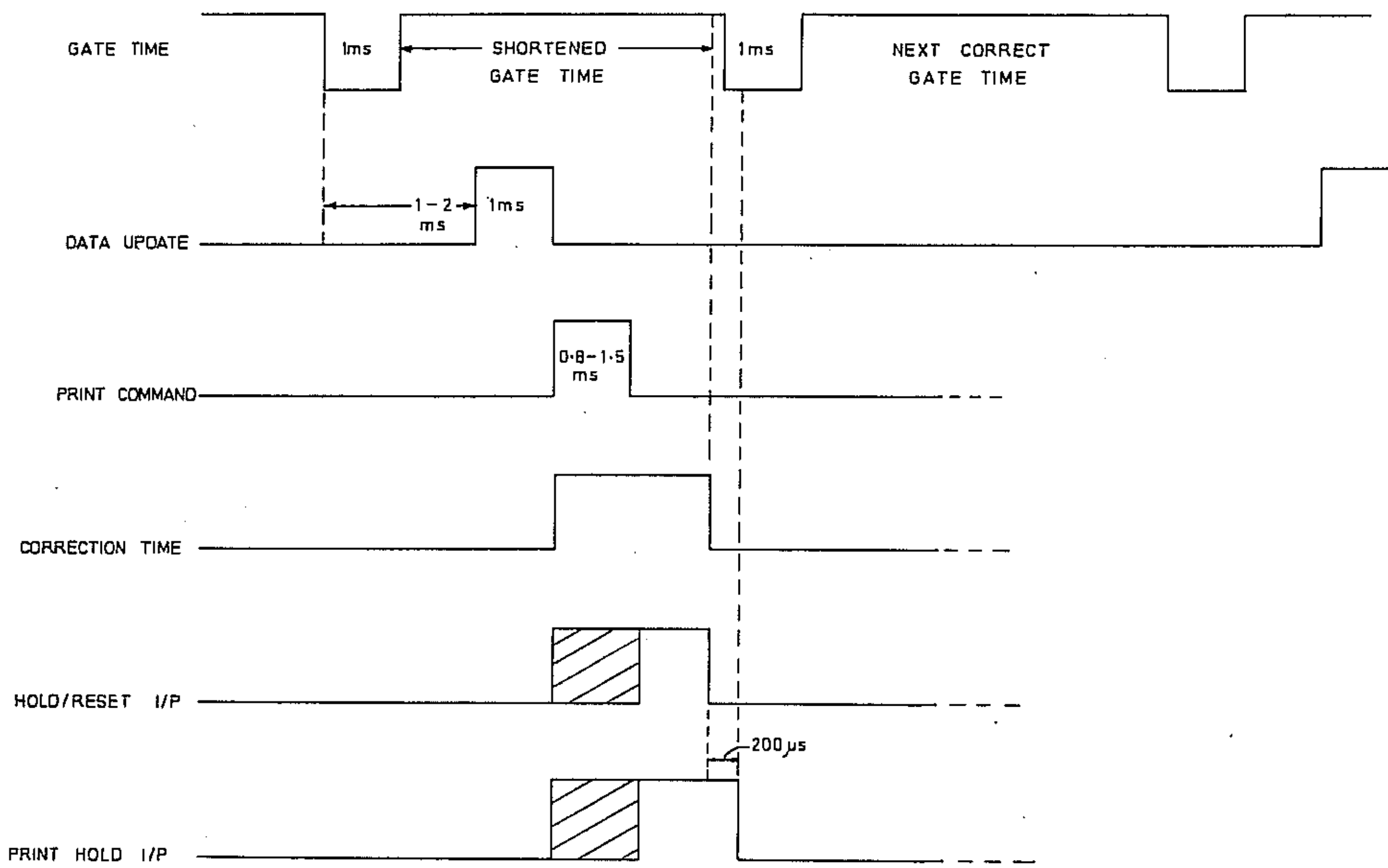


Fig. A4

TABLE 1.

FLYING LEAD CONNECTIONS

Pin No.		Pin No.	
1.	Not Connected	A	0V
2.	+ 5V (nominal)	B	$\overline{\text{OVERFLOW}}$
3.	KEYWAY	C	KEYWAY
4.	$\overline{4}$ BCD DATA	D	$\overline{1}$ BCD DATA
5.	$\overline{8}$	E	$\overline{2}$
6.	$\overline{\text{COUNTER HOLD}}$	F	Multiplex Sync (Note 2)
7.	$\overline{\text{COUNTER RESET}}$	H	$\overline{\text{MAIN GATE}}$
8.	DIGIT 10^8 SELECT	J	Not Connected
9.	Not Connected	K	$\overline{Z}$)
10.	Not Connected	L	$\overline{Y}$) TIME BASE
11.	Not Connected	M	$\overline{X}$)
12.	$\overline{\text{Ro}}$	N	Not Connected
13.	$\overline{\text{HOLD/RESET}}$	P	Not Connected
14.	See NOTE 1	R	Not Connected

NOTE 1. In option 01 units with serial numbers after 1389, pin 14 of the flying lead connection is connected within the interface unit to pin 43 of the 50 way connector. This permits a remote indication when instruments are in the divide by ten prescale mode.

NOTE 2. The multiplex sync. signal on pin F is 10 KHz, except with 9911 and 9919 instruments when it is 5 KHz.

TABLE 2.

50-WAY CONNECTOR

Pin No.	Facility		Pin No.	Facility	
1.	1		26.	1	
2.	2	10^0 DIGIT	27.	2	10^1 DIGIT
3.	4.		28.	4	
4.	8		29.	8	
5.	1		30.	1	
6.	2	10^2 DIGIT	31.	2	10^3 DIGIT
7.	4		32.	4	
8.	8		33.	8	
9.	1		34.	1	
10.	2	10^4 DIGIT	35.	2	10^5 DIGIT
11.	4		36.	4	
12.	8		37.	8	
13.	1		38.	1	
14.	2	10^6 DIGIT	39.	2	10^7 DIGIT
15.	4		40.	4	
16.	8		41.	8	
17.	OVERFLOW		42.	4	10^8 DIGIT
18.	1	10^8 DIGIT	43.	See table 1 NOTE 1.	
19.	HOLD CONTROL I/P		44.	8	10^8 DIGIT
20.	2	10^8 DIGIT	45.	1	
21.	$\overline{X}$		46.	2	DECIMAL POINT
22.	$\overline{Y}$	TIME BASE	47.	4	
23.	$\overline{Z}$		48.	PRINT COMMAND O/P	
24.	HOLD/RESET I/P		49.	PRINT HOLD I/P	
25.	0V		50.	+ 5V (VIA 180Ω)	